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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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SOCIETY OF AUTOMOTIVE ENGINEERS INC.
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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. II January, 1918 No. 1

The THIRTEENTH ANNUAL MEETING OF THE SOCIETY

MILESTONES in automotive progress—as such can be characterized the annual meetings of the Society. The proceedings of the Thirteenth Annual Meeting were limited to one day, but during the three sessions (business, professional and post-prandial), held on Jan. 10, matters of vital importance to the Nation, the Industry, and the Society were considered.

Evidence of the work the Society and its members are doing for the Nation appeared in the comprehensive standardization reports on aeronautic, tractor, marine, and other subjects; in the address delivered by President Dunham outlining S. A. E. activities during the past year; in the papers presented on the automotive fuel situation, the Liberty aviation engine, and the U. S. War Trucks; and in the addresses at the Annual Banquet, dealing with the U. S. aircraft program and with French automotive activities. The papers and addresses presented appear elsewhere in this issue.

The business session of the Annual Meeting was called to order by President George W. Dunham on Thursday morning. Second Vice-president Charles M. Manly gave a brief outline of the professional activities of the late Past-president Henry Souther, and presented a resolution expressing the loss to the Society in his death. This resolution was adopted unanimously by the meeting and it was voted to send a copy to Major Souther's family. The resolution follows:

"The Society of Automotive Engineers, having suffered great loss since its last meeting, in the passing of Major Henry Souther, U. S. R., Senior Officer of the Aircraft Engineering Division of the United States Army Air Service:

"The members of the Society, assembled in meeting at New York this January tenth, nineteen hundred and eighteen, hereby express tribute of friendship and affection for him, our Past-president and Standards Committee Chairman, our appreciation of his noble character, engineering ability and high professional ideals. He represented in spirit and accomplishment the best traditions of the Society. Thoroughly grounded in the science and practical application of engineering, hampered by no prejudices, fettered only by reverence for truth, and able to extract from conflicting points of view those elements of permanent value having relation to the tasks undertaken by him for the Society, as member, Standards Committee Chairman and President, he rendered pioneer and advanced service in the standardization of materials and essentials of assembly, which was of vital importance in the automobile industry, and stands as a monument to him. He established the work of the Standards Committee on such a firm foundation, conducted it so wisely, and extended its scope to such an extent as to make the later great success of the committee possible.

"Major Souther's work with the Aviation Section of the Signal Corps was fundamental in character. His foresight and imagination led to a conception of the vastness of the problems involved and to the evolution of an organization to cope with them.

"He was one of the greatest protagonists of mechanical standards this world has known. Essentially a leader, he turned with marked activity and with admirable zeal and honesty and elevation of purpose to the solution of automotive engineering problems for the Society and the country. The Society had no better friend than Henry Souther. His loss is very deeply deplored."

President Dunham appointed Ferdinand Jehle, W. H. Palmer, Jr., and F. S. Slocum to act as tellers to count the ballots cast for officers of the Society. The next business was the reading of Mr. Dunham's presidential address, which gave a description of the activities of the Society during the past year. At the conclusion of the address a motion was made and unanimously carried to congratulate Mr. Dunham for his successful activities as president of the Society and to express the gratitude of the members to him for his careful consideration of Society affairs.

An extensive report was presented by the Council Committee on Constitutional Amendments consisting of Councilor B. B. Bachman, chairman; Second Vice-president Charles M. Manly, and General Manager Coker F. Clarkson. The proposed amendments cover a revision in the present clause for grading of membership, provision for foreign grade and united service grades of membership, and for an additional administrative committee to be known as the Sections Committee. These amendments were duly proposed in writing and seconded by members of the Society. According to the provisions of C 56 of the Constitution of the Society, the amendments will now be mailed to the voting members of the Society at least sixty days previous to the Semi-Annual Meeting in June. They will then be brought up for discussion and final amendment, and afterward, if 20 members vote for them, will be submitted by letter ballot to all the voting members.

It was voted by the meeting that the following message of felicitation should be sent to the Institution of Automobile Engineers of Great Britain:

"Expressing great admiration for your effective and magnificent work in the war, the members of the Society of Automotive Engineers, assembled in Annual Meeting, send cordial greetings and felicitations. Enlisted in the common cause for democracy, we send assurance of co-operation to the fullest extent.

SOCIETY OF AUTOMOTIVE ENGINEERS."

REPORT OF MEMBERSHIP COMMITTEE

The following report was submitted for Chairman C. W. McKinley of the Membership Committee, and covers the applications approved by the Council since the last Annual Meeting:

Members	465
Associate Members	699
Juniors	159
Affiliates	37
Affiliate Member Representatives	74
Student Enrollments	71
Total	1505

A report was next presented by the Standards Committee on the matters approved the previous day at the meeting of the Committee. At the Society Meeting standards and recommended practices prepared by the Aeronautic, Motorcycle, Roller-Chain, Miscellaneous, and Tractor Divisions were presented and accepted. At the Standards Committee meeting held on Jan. 9 there was not sufficient time to consider the reports of the Lighting, Marine, and Tire and Rim Divisions; the meeting of the Society was therefore adjourned and a meeting of the Standards Committee immediately convened for the purpose of considering these reports. They were accepted and the Society meeting again called, with the result that they were approved for submission to letter ballot.

At the Council meeting held on the 9th a resolution was passed to the effect that all members of the Society who are in service abroad should have their dues waived for the remainder of the war. It was voted that this resolution should be approved by the Society. The resolution is as follows:

"The dues of members engaged in active foreign service, in military and naval commission, or enlisted or drafted capacity, shall be waived during the period of such service during the present war.

"The payment of dues of members, drafted, enlisted, or commissioned, but on service in this country, shall be subject to the provisions of Paragraph C 26 of the Constitution of the Society."

REPORT OF TELLERS OF ELECTION

The ballots cast by the members of the Society for officers during the current year were counted during the Annual Meeting. The list of officers elected follows:

President (to serve for one year), Charles F. Kettering, 551.

First Vice-president (to serve for one year), David Beecroft, 552.

Second Vice-president, representing motor-car engineering (to serve for one year), C. C. Hinkley, 539.

Second Vice-president, representing aviation engineering (to serve for one year), Geo. H. Houston, 541.

Second Vice-president, representing tractor engineering (to serve for one year), Fred Glover, 535.

Second Vice-president, representing marine engineering (to serve for one year), Henry R. Sutphen, 545.

Second Vice-president, representing stationary internal combustion engineering (to serve for one year), H. R. Brate, 546.

Members of the Council (to serve for two years), Charles S. Crawford, 550; J. V. Whitbeck, 549; Chas. M. Manly, 549.

For Treasurer (to serve for one year), C. B. Whittelsey, 552.

President Kettering was then called on and expressed his appreciation of the honor conferred upon him by the Society. He called attention to the fact that the automotive industry today is diverted from its normal activities and that plans should be made for the work that was to be done after the war is over.

Then followed the presentation of the professional papers, the first one being by Dr. E. W. Dean, of the Bureau of Mines, who spoke upon the mutual problems the automotive engineers and petroleum refiners should work on together to solve.

A symposium on the reasons behind the Liberty Aviation Engine was participated in by Col. V. E. Clark, Major J. G. Vincent, and H. M. Crane. Major Vincent afterward answered a large number of questions relating to the construction of the Liberty aviation engine. Owing to the lateness of the hour and the fact that the reception preceding the Annual Dinner was scheduled to start at 6 o'clock, it was possible to give only one of the papers on the reasons behind the U. S. War Truck design. Cornelius T. Myers described the general chassis design. His paper as well as those of Mr. Copland on transmission design, and Mr. Carlson on axle design, and Mr. Milbrath on the engine design are given in this issue.

Over a thousand members and guests attended the Annual Dinner, with the result that the banquet hall of the Biltmore Hotel was filled to overflowing. John Kendrick Bangs acted as toastmaster and Major Jesse G. Vincent, Capt. M. de Jarny, President C. F. Kettering and Chairman Howard E. Coffin of the Aircraft Board spoke on the problems now confronting the country, which the members of the Society can help solve.

For the first time in many years Society headquarters were established at the Automobile Show. A booth on the third floor was used to display some of the parts standardized by the Society as well as the S. A. E. publications. Staff representatives were on hand at the exhibit continuously and considerable information was given to members and others interested in the work of the organization.

REPORT OF THE TREASURER

The report submitted by Treasurer Herbert Chase of the financial condition of the Society for the fiscal year ending Sept. 30, 1917, showed a total income of $113,-227.97. The total expenses amounted to $96,297.01. While the greatly increased activities of the Society materially increased the expenses over the previous year, the income fortunately increased in about the same ratio owing in part to the marked membership increase, so that the net profit for the period was $16,930.96, a sum only slightly less than the income from initiation fees. It has been the desire of the Council for many years to permanently invest initiation fees and use only the interest from this fund toward the defraying of expenses. During the past two years this desire has been realized in large part and the Society now has invested in Liberty and other bonds $36,286.12. It will thus be seen that the Society's financial condition is excellent and quite in keeping with its other affairs.

Presidential Address of Geo. W. Dunham

WITH this, the Thirteenth Annual Meeting, the most eventful and perhaps the most important year in the history of the Society will be concluded. It has been a year of not only rapid growth but of remarkable accomplishments. It has been a year of attainment and patriotic service which can scarcely be duplicated if indeed it can be approached in the annals of any engineering society in this country, which rightfully boasts of the greatest engineering attainments of any nation. As a result the Society has attained recognition on the part of the Government not accorded to any other engineering organization, and has become in every sense of the word a national organization of which we as members may justly be proud.

Aside from the splendid work done by the Society in cooperation with the Government, perhaps its greatest attainment of the year has been the consummation of the plan for the unification of the engineering activities of all the automotive industries. The result of this important accomplishment will, I am sure, have a lasting effect of the greatest good in the history of the Society. The word "automotive" has now become almost as general as the term automobile and the coordination of the automotive engineering activities of the industries concerned is being reflected in a closer unification of the industries themselves. I shall not attempt to forecast the future, but marked benefits seem certain to result from the closer cooperation of all branches of the automotive industry.

The growth of the membership of the Society during the past year has been quite in keeping with its rapid expansion in other directions. The membership on Jan. 1, 1917, totaled 2120, while on Jan. 1, 1918, the Society had 3119 members on its roll, a net increase of 999 members or no less than 47 per cent, the greatest increase during any similar period in the history of the organization. While this growth is due in part to the broadened scope of the work of the Society, in absorbing the engineering membership of four other organizations, great credit is due to the efforts of the Council, our Membership Committee and the Sections, which have given untiring efforts to the recruiting of new members in the older as well as in the newer fields of endeavor. In addition, the Council, in cooperation with the Membership Committee, has laid plans for systematic membership increase work during the coming year, which is expected to bring in many strong men engaged in the automotive industries who have not heretofore fully appreciated the value of the work the Society is doing.

Committee Activities

In financial matters the Society has grown in proportion to its other activities. Details in this connection will be given you in the report of the treasurer. Suffice it here to say that although our expenses have increased considerably our income has fortunately increased almost correspondingly and the Council has found it possible to increase what we hope will be a permanent investment by the purchase of twenty-four thousand dollars worth of first and second issue Liberty Bonds. For this accomplishment much credit is due to the wise counsel of our Finance Committee.

As a natural result of our broadened activities, more meetings have been held than during any similar period in the history of the Society. Besides the highly successful and very well attended annual and semi-annual meetings, there have been held on Feb. 9, the first aeronautic session in connection with the Aeronautic Show, and the first and second tractor sessions held in connection with the Kansas City Tractor Show and the Fremont Tractor Demonstration respectively. All three of these special meetings were well attended and resulted in great good to the Society and the industries involved, as well as to those members who were able to attend. At the semi-annual meeting of the Society held in Washington the attendance was so great that an overflow session had to be held, while at the banquet that followed the meeting the entire capacity of the largest dining hall in Washington was more than sold out. The success of these meetings was due in large part to the splendid work done by the Meetings Committee, to which the Society owes a great debt of thanks.

In standardization matters the Society has done conspicuous service for the Government in the prosecution of its war program. The work of the Truck Standards Division of the Society was effective. The Government plan of establishing designs of war trucks involved considerable design work extending into the major units of the truck, a thing never contemplated in the standardization work of the Society. The Government put a large number of S. A. E. members to work, and the result has been the design of three sizes of completely new trucks. The achievement is one that has not been accomplished by any of the other allied powers and one which is bound to have a decided and beneficial effect upon the prosecution of war.

Aeronautic Standardization

Although the Society has not been so intimately connected with the furthering of the Government aeronautic program, it has nevertheless done splendid work in the creation of aeronautic standards, and the Government has members of the Society to thank in large part for the design and development of the Liberty Engine, an accomplishment that could hardly have been carried forward except for the missionary work the Society has been doing for years along standardization lines. In parallel with this development the Society has also through its Aeronautic Division completed the standardization of a number of parts entering into the construction of the modern airplane, and this work has been so well done that it is being incorporated substantially into the standards adopted by the International Aircraft Standards Board (on which the Society is officially represented) and the Aviation Section of the Signal Corps.

Work of a similar nature has been done by the newly created Motorcycle Division of the Society Standards Committee. Although the program of the Government in connection with motorcycle standardization is not yet so fully developed as that of truck standardization, a similar procedure is likely and seems certain to be quite as

successful. In this also Society members are doing the bulk of the work.

For patriotic reasons the major work of the Society in standardization, as in other lines, has properly been that done in the interest of the Government. This work will, however, have a decided effect upon the automotive industries after the war; and it is not by any means exclusively a war emergency matter, nor has it been done to the exclusion of other important standardization work. I cannot attempt to enumerate here all the standards created, but many of the divisions have done work of great credit to the Society. The Chairman of the Standards Committee and all the members thereof are deserving of our thanks and appreciation.

During the year there have been created no less than eleven new divisions of the Standards Committee. This amplification of the standards activity covers fully the newer fields of automotive engineering, and is bound to have a beneficial effect upon the industries concerned. In order to show the extent of our standards work, exhibits of parts made up to S. A. E. standards have been made at the automobile, aeronautic and tractor shows, and similar exhibits are contemplated at several of the trade shows to be held within the next few months.

The prosecution of the standards work has, of course, involved considerable expense and could hardly have been carried on except for the generous financial support accorded by the National Automobile Chamber of Commerce, the Motor and Accessory Manufacturers' Association, the Aero Club of America, and the National Association of Engine and Boat Manufacturers. We believe these organizations feel well repaid by the results accomplished. I desire to take this opportunity to thank them publicly for their support.

Work of Washington Office

The cooperation mentioned under the head of standards work is not by any means the only way in which the Society has been of assistance to the Government. Prior to the declaration of war on Germany by this country, the Council decided upon the establishment of the Washington office of the Society. The function of this office has been to render the most effective assistance possible to the Government and the members along automotive engineering lines. One of the most important things accomplished has been the taking of a census of the entire membership with a view to acquainting the Government with the qualifications of the members. The large number of blanks returned as a result of this census have been carefully classified according to the experience of the members, and have been made valuable to the branches of the Government service requiring men in either civilian or commissioned capacities.

As a result of this, in large part, something over 125 members of the Society have received commissions and are doing engineering work of the greatest importance for the Government, and an almost equal number are serving in a civilian capacity, while many more are giving a portion of their time to work in an advisory capacity. The work being done includes nearly every branch of the design, construction, inspection, development, repair and operation of automotive apparatus. I shall not attempt to catalog the numerous activities involved but one of the most important chapters in the history of the Society is certain to be that having to do with the splendid cooperation of our membership with the Government in the prosecution of the war.

The activities of the Sections of the Society have kept pace with those of the parent organization. The year has seen the establishment of two new sections, one in Buffalo and one in Minneapolis, both of which have held meetings of importance. The Sections Committee has done excellent work in correlating the activities of the sections, and the prospects for the future are bright. The work of the sections is properly regarded as one of increasing importance and it is to be hoped that members in all localities where sections are established will give them their hearty support. In localities where there are not a sufficient number of members to warrant the formation of a section, it is planned to hold occasional meetings which it is hoped will ultimately increase the interest in the work of the Society to such an extent as to warrant the establishment of sections.

New S. A. E. Periodical

With the growth of the Society a larger and somewhat more ambitious monthly periodical became desirable. The result has been the publication known as The Journal of the Society of Automotive Engineers, a periodical which has received the highest praise not only from our members but from other well qualified judges of technical publications. It should be realized however that the Society publications will necessarily be what the membership make them. Each member should therefore give the Society the benefit of his experience by the preparation of papers on automotive engineering subjects; these should include original research data, design and engineering data of all descriptions that will benefit the profession and reflect credit upon the Society through which they are published.

In order to carry on the enlarged and ever-increasing work of the Society the Council has considered it desirable to secure larger quarters, and has therefore arranged with the management of the Engineering Societies' Building for the lease of its entire sixth floor, excepting only one inside room which is not at present required. The Society will thus be housed in quarters befitting its size and importance in the engineering field.

In order to handle the increased volume of business done by the Society it has been necessary for the Council to employ a larger office staff. The work of the Society is thus enabled to go forward without encroaching unduly upon the members of the Society for the handling of work more properly handled through an organization created for the purpose. The untiring efforts of those thus employed are acknowledged and appreciated.

I have already referred specifically to work that the Society is doing in two of the newer phases of endeavor—the aircraft and farm tractor. Similar work is in progress in the marine engine field in which considerable standardization activities have been going on for some time. Plans for a meeting of particular interest to those in this field have already been announced.

Similar activities have also been planned for the members particularly interested in the stationary and farm engine field. A new division of the Standards Committee has been created to undertake standardization in this branch and other work corresponding to that already accomplished in the older lines of endeavor is contemplated.

I should not feel my duty complete if I failed to mention one severe loss sustained by the Society during the year. I refer to the untimely death of the late Major Henry Souther, past-president of the Society and for some years chairman of its Standards Committee. His untiring efforts in the interest of the Society will long be remembered.

In closing let me say that the extraordinary results

obtained during the year could not have been secured without the hearty support and untiring efforts of all the members of the Council, and the closest cooperation and efforts of our committees and the members of the Society in general. The good work must, and I am sure, will be carried forward through the officers of the incoming administration and the others chosen to represent the members on next year's Council. And I am sure that even greater success will crown their efforts for the Society, the automotive industries and democracy.

REPORT ON CONSTITUTIONAL AMENDMENTS*

THE Constitutional Committee of the Council has been requested to give consideration to suggested amendments to the Constitution covering:

1. Provisions for grading of membership.
2. The provision for a foreign grade of membership.
3. Provision for United Service grade of membership, and
4. Provision for an additional administrative committee to be known as the Sections Committee.

It has been felt that a revision of the classification of active members was desirable to permit broadening the activities of the Society by means of increasing the membership. Several suggestions to this end have been presented for the consideration of the Committee.

The first, which has been under consideration for the longest time, is an amendment to Paragraph C 8 of the Constitution, which would more clearly outline the qualifications governing admission to Member grade.

The second suggestion has been to change the designation of grading from Member and Associate Member to Technical Member and Industrial Member, the idea being that there was a certain class distinction between Member and Associate that would be more clearly indicated by the suggested change and that would appeal more to men of high standing in the industry who feel that their abilities and contributions to the industry have not been fully recognized when they are assigned to Associate membership, but who are not possessed of the necessary qualifications in a technical way to admit them as members.

The Committee feels, however, that this proposal would not cover the situation unless an amendment were made that would give the Industrial and Technical members equal powers with respect to holding office and voting; this would result in there being no difference between the two grades of membership and therefore no practical reason for a difference in name.

A third alternative is that all membership distinction be eliminated among the active members, the members of the Society to be divided somewhat as follows: Members, Junior Members, Affiliate Members, etc.

This suggestion has certain advantages inasmuch as it would remove the necessity of the Council deciding or using any discretion other than the acceptability of an applicant for membership. It is open to some objection on the score of being a revolutionary departure from the precedents established in the conduct of practically all engineering organizations. It has therefore appeared to the Committee that the first alternative is the only one that it can at the present time present to the Society for consideration. It is proposed that Paragraph C 8 of the Constitution be amended to read as follows:

"Member grade shall be composed of persons 26 years of age or over, who, by previous technical training or experience, or by present occupation, are qualified to act as designers or constructors of complete automotive vehicles, or their important component parts, or to exercise responsible technical supervision of the production of materials germane to the construction of automotive vehicles; or to take responsible charge of automotive engineering work, or to impart technical instruction in automotive vehicle design and construction; or who by reason of distinguished service or noteworthy accomplishment would, in the discretion of the Council, appear to be desirable additions to this grade."

The Committee feels that this amendment clearly outlines the qualifications for membership in the Society based on technical qualifications and still allows for the admission to full membership of men who by reason of their position in the industry are entitled to have a voice in the direction of its affairs.

It is proposed that Paragraph C 5 of the Constitution shall be amended to read as follows:

"The membership of the Society shall consist of Honorary Members, Members, Associates, Juniors, Departmental Members, United Service Members, Foreign Members and Affiliate Members. Honorary Members and Members are entitled to vote and to hold office, Associates, Juniors, Departmental Members, United Service Members, Foreign Members and Affiliate Members shall not be entitled to vote or to be officers of the Society, but shall be entitled to the other privileges."

After Paragraph C 10 the following new section shall be added:

"United Service Membership shall be composed of engineers 26 years of age or over, engaged exclusively by the Federal Government, the qualifications for this grade being the same as those for Member grade.

"Foreign Membership shall be composed of engineers 26 years of age or over, resident in countries other than the United States, Canada, Mexico or Cuba. The qualifications for this grade shall be the same as those for Member grade.

"A member who has become eligible for either the United Service Grade or the Foreign Member Grade may, upon written request, be transferred to such grade and thereafter, beginning with the next dues period, pay the annual dues for said grade."

Paragraph C 13 shall be amended to read as follows:

"The rights and privileges of every Honorary Member, Member, Associate, Junior, United Service Member and Foreign Member shall be personal to himself and shall not be transferable by his own act or by operation of law. Departmental Membership and Affiliate Membership also shall not be transferable."

Paragraph C 15 shall be amended to read:

"All original applications for election to the grade of Member, Associate, Junior, United Service Member or Foreign Member shall be presented to the Council, which shall consider and act upon each application, electing each applicant to the grade of membership to which in its

*Submitted at Annual Meeting by Council Committee on Constitutional Amendments. The proposed amendments were received and will be taken up again at the June meeting of the Society.

judgment his qualifications entitle him. Two negative votes shall defeat an election."

Paragraph C 20 shall be amended to read:

"The initiation fee for membership in each grade and for Student Enrollment shall be as follows:

For Member,	$25.00
For Associate,	25.00
For Junior,	10.00
For United Service Member,	10.00
For Foreign Member,	10.00
For Student Enrollment,	None
For Departmental Member,	100.00
For Affiliate Member,	50.00"

Paragraph C 21 shall be amended to read:

"The annual dues for membership in each grade and for Student Enrollment shall be as follows:

For Member,	$15.00
For Associate,	15.00
For Junior,	5.00
For United Service Member,	10.00
For Foreign Member,	10.00
For Student Enrollment,	3.00
For Departmental Member,	None
For One Affiliate Member Representative,	15.00
For each additional Affiliate Representative,	10.00"

Paragraph C 22 shall be amended to read:

"A United Service Member shall, upon discharge from the Service, promptly notify the Secretary of such discharge, and shall then be transferred to Member grade and shall pay the difference in initiation fee (providing he has not previously paid such fee) and thereafter beginning with the next fiscal period, pay the annual dues for Member grade."

"A Foreign Member shall notify the Secretary upon change of residence to territory rendering him ineligible for Foreign Grade, or temporary change of abode to such territory for more than six months in a given dues' period, and shall thereupon be transferred to Member grade and shall pay the difference in initiation fee for Member grade and thereafter, beginning with the next fiscal period, pay the annual dues for Member grade."

Paragraph C 25 shall be amended to read:

"Any Member, Associate, Junior, United Service Member, Foreign Member, or Affiliate Member, who shall leave the annual dues unpaid for three months shall not receive any publications of the Society until such dues are paid. Any Member, Associate, Junior, United Service Member, Foreign Member, or Affiliate Member who shall leave the dues unpaid for one year shall, in the discretion of the Council, cease to have any further rights of the Society and be stricken from the rolls of membership. The resignation of a member, whose account with the Society is not fully settled, can be accepted only by vote of the Council."

Paragraph C 26 shall be amended to read:

"The Council may temporarily suspend the annual payment of dues by any Member, Associate, Junior, United Service Member or Foreign Member, whose circumstances have become such as to make it impossible for him to pay the dues, and may under similar circumstances waive the whole or part of dues in arrears. Such action shall be taken only upon the written application of the Member, Associate, Junior, United Service Member or Foreign Member, signed by three other members in good standing, or evidence satisfactory to the Council that the action is for the best interests of the Society."

It is the intent of the amendments that the United Service and Foreign Member grades be strictly limited to persons possessing qualifications for full membership because the dues and initiation fees provided will mean that these grades will be carried at a loss to the Society. It is, however, felt that there is a real field for the Society to do excellent work and to put its information into the hands of desirable persons by this method.

It is proposed that Paragraph C 45 be amended to read:

"The President shall, within thirty days after taking office, appoint from the individual membership of the Society, the following Committees, designating the Chairmen thereto:

Finance Committee, consisting of five members.
Meetings Committee, consisting of five members.
Publication Committee, consisting of five members.
Membership Committee, consisting of five members.
House Committee, consisting of five members.
Constitutional Committee, consisting of five members.
Sections Committee, consisting of five members.
Tellers as required by the By-Laws."

At present Sections matters are handled by a committee consisting of a member of the Council, the chairmen of the various Sections and a member of the Society, who is a representative of the New York Office, acting as secretary. It is felt that the importance of the Sections work makes it desirable that these matters be handled by a standing committee of the Society appointed by the President under authority of the Constitution.

FORMATION OF MOTOR MECHANICS' REGIMENT

The United States Public Service Reserve of the Department of Labor has undertaken to raise a force of 7000 men for the Aviation Corps, these being required for service in France behind the lines in what will be called the Motor Mechanics' Regiment. It is believed that such men can be found who will volunteer for the work and who are not required in essential industries. Only men outside the draft age are acceptable under this call, so that they must be at least 18 and not over 40.

While all the men will be enlisted as privates a large number of non-commissioned officers will be required so that the chances for promotion will be extremely good. The Public Service Reserve is helping to secure these men, but they will be enlisted through the regular recruiting offices in the various states. According to the announcement sent out by the Reserve, 194 chauffeurs and motor-truck drivers, 3562 automobile and gas engine men, 1360 machinists, 220 blacksmith forgers, 220 wheelwrights, 504 cabinet-makers and 460 sheet-metal workers will be required for the Motor Mechanics' Regiment. These men will go at once into training to Fort Hancock, Augusta, Ga., and when trained will be sent immediately to France for service in the airplane repair shops and camps.

PART OF THE TEN HUNDRED AND FORTY-THREE MEMBERS AND GUESTS GATHERED AT THE ANNUAL DINNER OF
CAPTAIN

L DINNER OF THE SOCIETY. AT THE SPEAKER'S TABLE (LEFT TO RIGHT) ARE SHOWN CAPTAIN CRITCHLEY, MAJOR C
CAPTAIN DE JARNY, PAST FIRST VICE-PRESIDENT VINCENT, PRESIDENT KETTERING, GENERAL TOZZI AND LIEUTE

Major Orton, General Cormack, Past-President Coffin, Toastmaster Bangs, Past-President Dunham,
d Lieutenant Vezzani

Addresses at the Annual Dinner

THE Annual Meeting terminated on the evening of Jan. 10 with a dinner held at the Biltmore Hotel. Over one thousand members and guests attended. There were frequent patriotic demonstrations, and all of the speeches pertained to ways and means of helping to win the war. They are printed in full on the following pages.

Past-president George W. Dunham made a few brief introductory remarks, and introduced John Kendrick Bangs as toastmaster.

Mr. Bangs paid a glowing tribute to the part that this country has always played in the advancement of the highest ideals of democracy, then calling upon the assemblage to rise and do honor to the President of the United States and sing the National Anthem. Throughout the evening Mr. Bangs proposed toasts to our allies—Great Britain, France and Italy—which were responded to with applause. The wit for which Mr. Bangs is famous had free rein as he introduced the various speakers.

Major Vincent directed his remarks principally to the development of the Liberty Aviation Engine, and expressed appreciation of the cooperation that the Society had rendered in this connection.

President Charles F. Kettering then discussed briefly the present and future activities of the Society.

Captain de Jarny, representing the French Commission, drew upon his extensive experience at the battle front to discuss the status of the automotive industry in France, and expressed the heartiest greetings from fighting France to her American allies.

The final address was made by Past-president Howard E. Coffin, chairman of the Aircraft Board. He referred to the relation of the Government to the development of the automotive field, particularly as regards military aviation, and showed that the record of accomplishment, as compared to the prearranged schedule, has been excellent.

ADDRESS OF JOHN KENDRICK BANGS

I WONDER if those here have ever thought, in considering the United States of America, our continent, of what an extraordinary thing it has been that for all the myriads of years that have elapsed from the days when the earth first took form to a comparatively few years ago, that this continent was kept as a virgin soil by the powers that be, whether it be God Almighty or some forces that we know nothing of, for some divine purpose. And what was that purpose? For nothing else than it might prove an experiment station, for the promulgation, the planting and the growth of the seeds of liberty.

Have we ever realized that the discoverers of America —those who claimed to have been the discoverers of America—were not its discoverers? They were the men who only entered the vestibule of America. The first discovery of America was made by men who were seeking liberty—individual liberty, freedom of worship. The Pilgrim fathers and the cavaliers, the men of New England and the men of Jamestown, of Virginia and of the South—they came here for the promotion of individual liberty. Then years passed and another discovery of America was made by a German king, a gentleman by the name of George, who happened at that time to be occupying the throne of Great Britain. He discovered America and he discovered the America of self-reliance and independence, whose motto was that Britons never will be slaves. And the liberty of the State was established by the noble spirits of the Americans of that time, under the leadership of our great President, George Washington. That was the second step in the progress—the liberty of the individual, the liberty of the State.

And then we reached another period in which another great individual, a great President, discovered America, when he discovered an America that was half-slave and half-free, and he said, "This must not be; this nation cannot survive half-slave and half-free." And in pursuit of that ideal Abraham Lincoln made the American continent free! The third step! The individual, the State, the continent, and another period of time elapsed and America was discovered by another President of the United States, William McKinley, who discovered that the hemisphere was not free, and the American people came forward with a fealty to high ideals of the finest type and said, this hemisphere cannot exist half-slave and half-free, and Spain was ejected from the Western Hemisphere, and we had a hemisphere that was free. The fourth step!

And, what is more natural than that the fifth step should now be coming to us, as the greatest opportunity that has ever come to mankind, in which we are permitted to associate ourselves with our noble Allies upon the other side of the Atlantic Ocean? The men of Britain! The men of France! The men of Italy! Why? That the individual should be free? No! That the State should be free? No! That the hemisphere should be free? No! *That the whole world should be free!*

That is the progression and that is why we have been held in reserve to come along at a critical moment with all our resources, with all our souls, with everything that is within us, to help our noble Allies in standing in the path of the ravening beast of Potsdam, who would place his bloody paw upon the necks of the free people of God's beautiful earth. It is to the everlasting honor of the American people that at the time that this opportunity has come to us we have in the White House a man who, by his lucidity of thought, by the clarity of his expression, is able to make himself the protagonist of the liberties of men in such fashion that no hide-bound oligarchy or aristocracy in any civilized world can for one moment possibly misunderstand the high and honorable aims that have led us into this war.

ADDRESS OF MAJOR VINCENT

I WOULD like to say a few words about cooperation, because I believe that this Society, probably more than any other that I know anything about, has stood for cooperation from the first. The men who founded this Society had a vision of automobile engineers working together on standardization and cooperating to produce a better automobile.

The Society has gone on until now it embraces all of the automotive industries. The members of this Society have shown a fine brand of cooperation during the last few months, and I believe that they are now beginning to realize some of the fruits of their labors. I know that it has been brought home to me during the past year, and more particularly during the last few months. When I was called down to Washington about the middle of the year on some engineering matters, the Govern-

ment was at a point where it had to make some decision about aircraft work. The Aircraft Production Board had temporarily taken up the work until some more definite form of organization could be perfected.

I happened to be one of the fortunate ones that were detailed to go after the aircraft situation, with particular reference to the engine. I am not going into any details here, but shall say just a few words about the development of that engine and the cooperation that made it possible.

After giving the matter careful consideration, and in light of the information brought to us by our friends from the other side, it was decided to design a standardized American aircraft engine. That was decided as being necessary, because at that time none of our friends from the other side were ready to recommend the one engine that they thought would be satisfactory for our work. We knew that if we were to get the full value from our American resources, we must design an engine that could be built to the best advantage in an American shop, under American conditions, with American workmen.

Now, just a word as to how that engine was built. After we had made our layouts and the Aircraft Production Board met in session with the Joint Army and Navy Technical Committee, we were given a "go ahead," and in exactly 21 days we produced an eight-cylinder engine (that was from the beginning of the patterns to the completion of the engine), and it was shipped to Washington.

That was due to cooperation and nothing else. I was fortunate, of course, in knowing just where I could get a certain thing made. The parts were made in factories all the way from New York to San Francisco. We selected factories that were, so far as possible, making a similar article, but, of course, in most cases, that didn't do the particular factory much good in turning out the article, because the parts of necessity were all new.

We had the cylinders made in Detroit, and we had to send to Cleveland to get 8-in. round stock and "hog" the cylinders out from that; nevertheless, those cylinders were finished in nine days. If anybody anywhere along the line had stopped to ask a question as to why they were to make that part that certain way there would not have been any engine at the end of 21 days.

I sometimes like to look at the military organization and wonder why it is organized as it is. I do not know much about military matters, but I think I know why it is so organized. When a general is on the battlefield and gives an order, and that order is relayed down through a number of officers, it must not be changed in any respect, it must not be held up, nor delayed.

That was exactly the case in the building of the Liberty engines. There were two of us entrusted with putting the work through, and we stayed on it till the job was done. There was not any one anywhere along the line who blocked the game. I think they did not know how much authority we had, but, anyway, they did not question it. Later on, of course, there were a few criticisms; a few people thought they had not been properly considered in the designing of the engine so that their equipment might be used. I have had some letters of that kind, but they are few, and in every case an explanation from myself as to how the job was done and promising that we would give the matter further consideration as soon as possible has satisfied them. That is the kind of cooperation that will win this war.

Now, this standardized engine may be a great deal more important than just being a standardized engine. I have said time and again that this is a toolmakers' war, and we have to conserve our toolmakers and the tools that they make. By that I mean that if we have an airplane with thousands of dollars' worth of tools for making the fittings and we want a different kind of an airplane, we must, so far as possible, select fittings from that airplane and weave them into a new one. That will not always be possible, but it will be possible to use a great many of them.

The same thing is true of the engine. I think there will be no other engine cylinder made during the war. There may be different combinations of those cylinders, but the cylinders and the valves and the valve-operating mechanism, and, in fact, 95 per cent of the engine I believe will go through without change. We have immense facilities that are now producing or preparing to produce parts of these engines.

Just stop and consider how different it would have been if we had turned the proposition loose and said, "We will turn over half a dozen copies and design them, or we will turn the copies over to some one to design the engines." I think it could not be possible to design a better engine, because no one could possibly have gotten better information than we had. In fact, not only had we information regarding all the engines in the world at that time, but our good friends from the other side also brought over the experimental data. We believe our engines, when they reach Europe, will compare favorably with what will then be produced over there.

On account of the fact that we finished this engine so quickly and that immense facilities are available we will soon have quantities of engines. In fact, regular production has started.

The plane proposition was a little harder, because we must have a number of different planes. We will not, of course, attempt at first to build all the different kinds of planes that are used in Europe, but we will start to specialize on those planes that do not change so frequently. I mean by that the larger planes. The little single-seated fighting machines are more of a specialist's job—they correspond more to a racing car, and we must be near the track if we want to develop a racing car. I think that we will not do much in this country toward building the little single-seater combat machine, but we can do a great deal of good on types of machines that do not change very markedly and on which large production will be a big factor in winning the war.

ADDRESS OF PRESIDENT KETTERING

WE have entered into a tremendous contest. Our country has one outstanding advantage, and that is her ability to produce large quantities of interchangeable apparatus. Outside of that, we have our tremendous natural resources, but I do not believe that there has been developed in any other country that one thing so universal to American manufacture as the idea of interchangeable parts.

The Government of the United States has asked us to produce enormous quantities of apparatus to serve in this war, and especially of the automotive type. I do not believe that there is any one of us in this organization who has not either legitimately or illegitimately uttered more profanity about some of the things that they have asked us to produce than would be fit to mention. There has not yet been fully established between the people at Washington who have designed apparatus and the manufacturers a full understanding of what each can do and what each ought to do.

The one thing that is handicapping our production of war materials today is a lack of understanding of what are the limits necessary to make interchangeable parts. If there is any one thing that the S. A. E. can do that will do more good than anything else at the present time, outside of producing the apparatus, it is to give honest, conscientious, constructive criticism to the people who have designed these limits, who have made these drawings, and who have not fully understood the manufacturing end of it. We are all prone to criticize, and we have talked about this thing, but I have not yet found a single instance where those limits have not been changed so as to make production possible, if we took that particular thing that was causing a manufacturer trouble and brought it to the proper authorities in Washington.

Thousands of factories today are really letting the bugaboo of a little limit that they do not understand hold up their production and are unconsciously finding fault with the people who have designed it.

Something else that I want to mention is our tendency to criticize many things we do not understand. That is human nature. I have heard much criticism of the Liberty engine and of the U. S. war truck. If we have a criticism of those things to make, the best place to go is to the fellow who made the truck and not to everyone else in the community. Or, if we think this Liberty aviation engine isn't right, let us tell the men who designed it. One of two things will happen if that is done; either we will make an improvement on the truck or the engine, or we will learn something ourselves.

This Society has some great problems before it. At present practically all our energies are diverted from normal commercial lines, and we are going into new business in the building of munitions, or what not, for the Government. The conditions that govern our business when the war is over will not be the same as when we entered it. Therefore, it is necessary for some members of the Society to be analyzing and projecting, if possible, and bringing before the Society those problems that we will have to solve.

The only time people criticize gasoline is when an engine is designed and someone else advertises that it will do twice as much as it can, and then the blame is placed on the gasoline. But the problem of a scarcity of fuel has never reached the country before. The tremendous volume of fuel demanded has reached a point where we are just balancing our supply and demand. The tractor industry is coming in, and we will see the time, if the fuel and other problems can be solved, when it will be as much of a sight to see a horse draw a vehicle as it is out in our country to see an ox draw a vehicle.

The future of the internal combustion engine for rendering itself useful to mankind depends upon a complete analysis of fuel problems. Efficiency of engine design and all such matters must be made fundamental problems, and, as time goes on, with the extensive work that has been done in standardization, with the broad knowledge gained of how to standardize, our standardization work will become the routine work of the Society, and the great constructive work will have to be done in research and in solving the problems that will sustain the industry for the new work that it has to do.

There is being poured in and out of this country a stream of information and of engineering data such as has never been heard of before, and we ought to have these things in mind, so that we can avail ourselves of such information as would be useful.

We have no doubt within the Society every bit of knowledge and information necessary to the solving of any of these complex problems, but we have not worked together, we have not had the problem in common, and that is the thing we ought to start doing now.

I believe that sometimes when we understand what it is possible to do with fuels and with changing designs of engines, we will be surprised at the tremendous future in front of the automotive industry. There is no limit to it. Never in the history of the world has man been given such a tool as the internal combustion engine. It has absolutely changed our whole method of living. It has changed our social conditions and our economic conditions, and it is not only necessary from a commercial standpoint that we give the fuel situation consideration, but it is absolutely imperative from every standpoint that it be given the proper consideration.

ADDRESS OF CAPTAIN DE JARNY

I MUST remember that when I am not a soldier I am an engineer, and I am proud to have had the honor conferred upon me of becoming a member of your Society last summer.

It has been said that the Republic of the United States of America is a grateful republic. No nation more than France can vouch for that statement. We have felt, first of all, even before war was declared by the United States, that in the hearts of many Americans there were the kindest feelings for France. I have seen the proof of that—by the generosity lavishly poured upon the population of our devastated country and by the eagerness of so many young men who have abandoned positions and have come to France to drive ambulances and make themselves useful. Since the war, of course, we have been working hand-in-hand, so much more than we could ever before.

France has been saved by its own automotive industries, although in our country the automotive industries are, of course, of a size that cannot be compared with the size of the automotive industry in America.

After France was subjected to the foulest attack made upon her or upon any peace-loving nation in history, our richest departments, those producing steel, coal, all the raw materials and the heavy engineering were absolutely laid bare. Our enemy was stopped at the gates of Paris, but he did not enter Paris. Paris, fortunately, is the center of our automotive industries. After the first shock, a sort of stock taking was made of our resources. They were limited, yet everybody set to work and all the shops, factories, small and large, began to manufacture first and foremost munitions.

At the beginning many disappointments were the result of the attempt to manufacture such munitions. The first difficulties were overcome, and, while continuing to produce munitions, with the crudest methods or rather with no methods at all but simply producing them the best we could, methods were devised, organizations were planned and new factories built up by the same men who had made the first start. And finally, after months of struggle, we reached that point where the supply of munitions was equal and even superior to the demand.

In the meantime, the demand for real, purely automotive goods, such as trucks, automobiles and the like, which was growing at a fast pace, could not be met by our own factories, which were and had to be devoted exclusively in many instances to the manufacturing of guns and ammunition. We came to this country and found a ready response. That is particularly due to the work of this Society, which has carried out standardization to such a high pitch that it was possible to get from

this country, from the various manufacturers, all that we needed in the way of automobile trucks and even lately of aviation engines.

On one hand standardization has had much to do with the construction of the Liberty engine, which I consider one of the finest features of engineering; on the other hand the question of the replacement of parts and accessories is dependent upon standardization, and standardization surely greatly simplified that problem.

We can hardly realize what it means at the front, in the various places where the rolling stock of the army has to be repaired, what the benefit, the blessing, of standardization means. It has saved us innumerable hours of time and also a large amount of money.

Now, I wish to give a few personal instances relating to the development of the automotive industry at the front. When we started on Aug. 5, 1914, for Belgium my division possessed, I believe, three automobiles, of which one was the personal property of the general commanding the division. Now, a division of infantry has a large fleet of staff cars, not for joy-riding—there is no joy-riding on the roads at the front—but for actual, real work. The division has motorized ambulance columns, motorized ammunition columns, motorized supply columns—everything motorized.

The same remark applies to aviation. We had a few airplanes at the beginning, and we felt often during those few first days that the Germans had too many of them. But now it is the reverse. We feel in perfect safety. That does not mean, of course, that we must rest upon our laurels, as we say in French; we must work hard, because our enemies are also working hard, but we will meet them on the field, because it cannot be said that, with the help of the greatest engineering nation in the world, the United States of America, their allies, that is ourselves, could ever be wanting for anything in the line of engineering.

Many members of the Society, I am told, are engaged in manufacturing various classes of munitions. Sometimes they will meet some disappointment. There are, as Mr. Kettering said, fine limits to be contended with (rightly or wrongly, I will not discuss now), there are methods that are imposed by specifications, and often points escape attention, because of lack of familiarity with questions pertaining to ordnance. It is necessary to be patient and to work in cooperation with the army people to make a good job.

After success has been attained, which will certainly be the case, the members of the Society will find that they have broadened the scope of their engineering ability; they will have to modify the organization of their factories, but after the war they will be prepared for any contingency, and, as Mr. Kettering has said so rightly, we can hardly know what will happen after the war in the way of engineering. There are immense possibilities, and the automotive industries will probably develop in a way of which none of us can even now dream.

The agricultural tractors, which two or three years ago were hardly known, and which were a subject of suspicion with the farmer in this country and still more with the farmer in the old country, are now an accepted fact. One of the reasons for this is the absolute lack of horses, badly felt now and which will be felt still more after the war. We can consider that the agricultural tractor has come to stay. This means such a tremendous number of machines to be constructed that a large portion of the activities in this country will have to be devoted to that work after the war.

I have the great privilege to speak on behalf of the French Commission. I am speaking on behalf of fighting France, our friends who are over there in the trenches and who have had the great privilege of greeting their American brothers—on behalf of these boys, our boys, I bid S. A. E. members good luck in the work they have undertaken. I wish them every success, because upon theirs depends the success of our armies. With them as collaborators and with their support, we can face any attack and we can wait with calm for the day of peace, which will be the day of victory.

ADDRESS OF PAST-PRESIDENT COFFIN

I WONDER if any of us realize the responsibilities that rested upon the shoulders of a group of half a dozen men in Washington about the 1st of June, only six months ago, when certain general policies with regard to America's participation in the European struggle were determined upon. In this particular instance there was a realization not only that we were obligating hundreds of millions of dollars upon the outcome of this work that was to be performed, but also some, perhaps, thousands of lives of Americans. We were acting in the full realization that sooner or later this country would have to supply engines not only for the aircraft forces to be put into the field by us but also for the allied countries.

Based partly upon the representations of this group of men and their decision that in this country lay the ability to build the best engines in the world, a great appropriation was made last July. We have just recently seen mentioned in the papers the fact that this appropriation, great as it was, is to be followed with one billion dollars more, also to be devoted to the development of the air service.

Some idea of the size of the job can be conveyed perhaps by calling attention to the fact that in 1912 the sum of $125,000 was voted for aeronautics in this country; in 1913, $100,000; in 1914, $125,000; in 1915, $250,000, and in 1916, $300,000. In short, in all these years, a sum about sufficient to equip and maintain in the field for one year, under modern conditions of service, one flying squadron. Such was the background that those who were undertaking the expansion of the aeronautical industry in this country faced when they knew that the decisions that were made in June would be the basis of appropriations totaling for the army about $789,000,000, plus about $50,000,000 for the navy, or $839,000,000 in all, and that we faced an industrial development—and, after all, at least seven-tenths of the whole business of war is industrial—more than twice the size in financial value involved in the digging of the Panama Canal, in which were engaged some thirty thousand men for eight years.

Society Preparedness

I wonder, too, if the members of the Society realize just when they began to work on this proposition. They began to work on it actively in June, 1916, on a memorable trip of the Society of Automobile Engineers up the Great Lakes. On this particular trip was hatched the idea of a Society of Automotive Engineers, wherein the

activities of this engineering organization would be devoted equally to the development of the aircraft art, the motor tractor, the motorboat art, along with the motor-car art.

I think that none of us was doing much more than guessing that sooner or later we were going to be involved in this war, but if we had had an announcement in June, during that trip, that the members of the Society were going to be asked by the United States Government to build tractors, to build tanks, to build aircraft, to build coast-patrol boats, and all of the other things that involve self-propulsion, I do not believe that the action of that organization could have been taken with any more wisdom. When we look back, in the light of present history, and see some of the steps that this organization has taken, leading to a closer cooperation of the engineering brains of this country, and to a closer coordination of effort, I do not believe that we could have worked to better advantage had we been deliberately planning in those days that the strength of America was to be thrown into the scales in this great fight for the liberty of all nations.

Aircraft Production Board

I would like to trace some of the developments that have led to the situation as we face it in this month of January, 1918. Along last April, the National Advisory Committee for Aeronautics, which was created by Congress, and appointed by the President, to report to him as his personal advisor in matters pertaining to aviation, felt the need of coordination between Army and Navy air services in industrial matters. It was realized that, without reflecting in any way upon the ability of the officers of both of these services, in war as now waged, the industrial element must be given the most prominent position.

Consequently, in a written communication addressed in April by the Committee to the Council of National Defense the suggestion was made that there should be formed an Aircraft Production Board, made up of those officers of the navy who have jurisdiction over aircraft, those officers of the army who exercised a similar jurisdiction, and a group of industrial members who had knowledge of quantity production, particularly in lines allied to that of aircraft, and with special regard to the development of engines, because it was realized by both branches of the service that the creation of engines for aircraft was perhaps the most important development.

About the first of June the Aircraft Production Board was organized, and one of the first steps taken by this organization was to call to Washington a group of men who, in the opinion of the members of that Board, represented a rallying point for the engine building industry of this country.

The result of this is already known. Major Vincent has described the development of the engines and the reasons therefor.

It has been said that the first Liberty engines, which had eight cylinders, were failures, and had to be discarded, and that the American Government has built less than half a dozen aircraft suitable for service over the fighting lines in Europe. In such an authoritative source as the *New York Times* the statement has been made upon the best authority that even if the reliable aircraft and reliable engines are now developed and ready for production in this country it will require at least one year to train the technical personnel required to keep them in repair after they have been shipped to the front. In view of these statements I want to present to you some of the actual facts.

I doubt whether it is realized just where the sources of much of this criticism lie. Activities are going on under the surface in this country to discredit everything that is being done in the line of preparation, to instill distrust in the minds of the American people, to make them doubt the capabilities and capacities, and actually, in many instances, the honesty of the men who have been put on the job to accomplish that which the American people, through their Government, have assigned to them. The motives of many of the members of the Council of National Defense have been assailed. Accusations have been made that their positions have been used to influence the placing of contracts where the benefits and the profits arising from the execution of these contracts would reflect to the benefit of the members of the committees in Washington. I can assure you that from two years of close association with this work, and from a year's association with the men who have been called to Washington to serve in an official and semi-official capacity, in aid of the governmental departments, I have yet to see a single instance in which I felt in my own mind that there was the faintest suspicion of doubt as to the honesty of action or honesty of advice that had been given by these men to the United States Government.

Work of Council of National Defense

I do say, and history will bear it out, that had it not been for the creation by Congress of the Council of National Defense, which for the first time in the history of this country provided a channel through which the industrial brains of this country could be mobilized in the support of the governmental departments, our military program would certainly have ended in near disaster. Our ability to call upon engineers and leaders who have been instrumental in the upbuilding of the great industries of this country, which, after all, must become, and have become, the whole backbone of our preparation for war and of our ability to wage war, has been the one element that has tided us over the period of shock, the chaotic period that necessarily followed the declaration of war, and the sudden necessity for the expansion of every department of the government from a peace-time basis to a war-time basis. If the work of these men has tided over that interval, then they will have done the greatest work that they can ever do for their Government, and the opportunity has been afforded to the military departments to reorganize and put themselves upon a basis upon which they must be put to combat an industrial machine such as that found in enemy countries, which has been built up over the last fifty years.

Between June 1, 1917, and Jan. 1, 1918, we have seen the development of aircraft from the eight-cylinder, low horsepower stage of which Major Vincent has spoken, to the high horsepower type of fighting machine, which necessitates the use of engines of powers that were little more than dreamed of in June of last year. Had we built a thousand or five thousand machines for service of the types specified in August, we would have been shipping at that time planes in no way in keeping with the development of the aircraft industry under the forced-draft methods of the war in Europe. We are starting in the period of quantity production in our program with machines that are the equal of anything in Europe.

Duties of Aircraft Board

I want to say a word as to the organization of the Aircraft Production Board and as to the organization of that governmental body which has resulted from it, the

Aircraft Board. The Aircraft Board is a coordinating influence between the War and Navy Departments. It does not, within itself, execute orders; it is an advisory body. There sit upon this Board the executive members of both War and Navy Departments as related to aircraft development. The determination of policy upon the part of the Board is put into execution through the duly organized departments of the Government, and not through any organization built up under the Board. Consequently, the actual task of putting these policies into execution and of putting designs of engines and airplanes into quantity production in this country are functions of the duly constituted governmental departments. The War Department is charged with the actual execution of the orders; the Navy Department is charged with a similar authority and responsibility. The Board is by law charged with supervision and advisory powers, but is prevented from building up any organization under itself for executive work.

To quote from the act of Congress establishing the Aircraft Board:

"It is created for the purpose of expanding and coordinating the industrial activities relating to aircraft or parts of aircraft, or products for any purpose in the United States, and to facilitate generally the development of the air service—that the Board is hereby empowered under the direction and approval of the Secretary of War and the Secretary of the Navy to supervise and direct in accordance with the requirements prescribed or approved by the respective department, the purchase and manufacture of aircraft engines, etc.

"Provided that the Board may make recommendations as to contracts and their distribution in connection with the foregoing, that every contract shall be made by the already constituted authority of the respective department.

"Provided further that, except upon the joint and concurrent approval of the Secretary of War and the Secretary of the Navy, there shall not be established or maintained under the Board any office or organization duplicating in whole or in part any office or organization now existing that can be properly established or maintained by appropriation made for or available for the military and naval services."

Theoretically the Aircraft Board is charged with advisory powers in connection with the industrial development of the aircraft industry. It is not, by Congressional enactment, charged with any responsibility in connection with the military side of the program, but, being constituted by the executive officers of both services, the Board has automatically come to be the clearing house in which are determined or discussed many of the military policies. These include the question of the training of aviators, the training of mechanics, the construction of the great flying schools that are going up almost over night in various parts of the country, and with many other lines of work not properly connected with the industrial development as such.

I think that sooner or later, and much sooner, undoubtedly, than most of us think, a force required for the air service will be in excess of the combined force of the Army and Navy of the United States twelve months ago.

NOTE.—When this statement was made, the Secretary of War announced that the air service has increased in personnel in eighteen months from 333 to 82,000.

Air Service Policy

The policy of the development of the air service connected with the war is as follows:

"1. The United States to establish and maintain a great system of training stations, adequate both in ground schools and flying schools, to provide preliminary training for the personnel schedule."

Twenty-four of these schools were authorized under the bill, and a large proportion of these are already in service. Their construction was scheduled to take place so that they could keep pace with the development of personnel and with the development of training planes.

"2. To accomplish an international standardization in aircraft materials, in detail of design and types, and to achieve such coordination of effort as would concentrate the manufacturing facilities of the various allied countries upon the minimum number of types of those machines for which the producing equipment was best fitted."

International specifications for aircraft materials have been prepared under the direction of the Board by a committee representing the Allied countries. A complete coordination of manufacturing facilities and policies has been agreed upon between the Allied powers. Standardization in types, designs and materials will continue to be carried forward under international agreement already in effect.

"3. To construct primary training machines of quality and quantity approved by the Joint Army and Navy Technical Committee."

The production of standardized training machines approved by the Joint Army and Navy Committee will be in excess of the needs of the training program before Jan. 20, and many hundreds of planes will be stored before the end of the month. The production of these machines has been behind schedule to date because of the necessity of supplying training engines from this country to meet Canada's considerable requirements and because of the difficulties of the sudden increase of a manufacturing industry inadequate to the task.

It was considered more important, in the joint effort in which we are engaged, to keep the flying schools of Canada going at full blast during the past six months, where they were training some hundreds of our flyers and some thousands of our mechanics, than to cut off that supply of machines and start new schools in this country, where our efficiency could not by any conceivable imagining be equal to those already in full operation just to the north of us.

"4. To provide, equip and train personnel for flyers and mechanics in accordance with the Army and Navy program."

This program is progressing almost exactly on schedule. The training of both flyers and mechanics is provided for in this and in allied countries, and thousands of mechanics are being put into active service where they will get the training, which, after all, is what counts most when dealing with realities behind the battle front. Several flying schools are being utilized as training schools for mechanics, in accordance with the plan laid down in June, a plan that has never been varied.

"5. To provide raw and semi-finished materials and finished parts, including engines, to insure the consummation of the augmented allied aircraft building programs."

This has been and is being done. All of the allied nations are in considerable degree dependent upon materials and parts shipped from the United States, and it is vitally important that the American aircraft program be not permitted to interrupt this flow of material to the Allies.

"6. To provide for the equipment of the American

forces in France for the period of January to June, 1918, in large part by purchase of fighting machines manufactured in allied countries, and to supply the machine tools and raw and semi-finished materials necessary to insure their production."

This step was taken to safeguard any manufacturing program in this country, because it was realized that even with the record-breaking development that has taken place in connection with our American engines we could not hope to have them in quantity production in this country before about this time.

One of the first acts of the Aircraft Board after the passage of the appropriation bill in July (and I would like to point out that July 24, the date of the signing of the bill by the President, marks the beginning of aeronautical history so far as quantity production and development is concerned in this country) was the sending to Europe of a comprehensive technical committee composed of more than a hundred engineers, shop foremen and mechanics.

"7. To provide completed service machines, including combat and bombing types, for American needs after July 1, 1918, and for such shipment of the finished product overseas as tonnage might permit."

It was realized that aircraft that might be built in this country prior to that time for actual service at the fighting front would be, must be, in the nature of a surplus supply, and that the first safeguard for our troops in European countries must be in the machines for which provision was made nearly six months ago for construction under the direction of General Pershing.

The Secretary of War announced at the time the placing of orders for some 5000 machines in Europe, and machine tools and materials are being shipped for this purpose.

Reorganization of Government Departments

The part that this country is to play in the manufacturing program of the joint air service is being considered by inter-allied conference and agreement. To each country is being assigned the work for which its equipment and facilities are best fitted. Individual initiative in aircraft manufacturing programs must in large degree be subordinated to that coordination of method and standardization of material that will insure the achievement of the common end. What percentage of machines can be shipped finished from this country and what percentage of machines must go in their component parts for assembly overseas must be decided from time to time in accordance with the demands for the tonnage.

Now, one other development has come to us. In accordance with the originally laid plans, primary training only was to be undertaken in this country, and advanced training was to be conducted overseas. So rapidly have men of the air service been supplied to the facilities made available to us by the Allies that we have now been asked to institute advance training at the earliest possible date here, because of our filling up of the European facilities set apart for us. There is no difficulty in connection with the advance training program. That is in hand, and the machines for this purpose will be available to meet the need.

We have talked a great deal in this country about the hundred thousand airplanes that are to be supplied from this country within a year for active service at the front. In Allied service today there are some forty men in the auxiliary services of the air branches for each machine at the front, so that the maintenance on our part of a force approximating four millions of men to take care of the repair and upkeep of a hundred thousand airplanes would be a considerable problem.

This is simply a period of development with us. There is no use of our blaming the military departments. There is no use in our blaming Congress. There is no use in our blaming the Senate, because, after two years of more or less intimate contact with these law-making bodies, I find that they reflect the attitude of the great American people behind them, and that they move quickly when the sentiment of the American people favors action. And another thing, a peculiar thing, about Congress and the Senate, contrary perhaps to the public conception, is that when they do move and have been given the real facts upon which to base action, the action they take is, after all, an action that is about the best thing to be done.

Society War Activities

I cannot close without saying a word of a heart-to-heart nature with the members of the Society. I believe we are willing to admit that we are about the most progressive, as well as the youngest, of all of the engineering organizations of this country. I believe that we are willing to admit that, as a practical matter, we have perhaps accomplished more for the benefit of the industries with which we are closely associated than have any of the other engineering organizations of this country. I believe that this organization, this Society of Automotive Engineers, has had a greater part in shaping the war program of this country, has had a greater part in developing the mechanical side of the war program of this country, than have all of the other engineering organizations in this country put together. I do not make that statement loosely. I do not make it to reflect upon any other organization, of which many of us are members, but this organization has had a faculty of keeping its feet down on earth, of appointing committees that would work, and of saying "yes" and "no," which, after all, in this country at the present moment is above everything else the greatest faculty and the thing most needed in the conduct of any war. It is decision and it is real action that will win this war; it is not the decisions of committees that are appointed to consider scientific matters and report some time in the future. The things that will count are the actions of men who get on the job immediately when the need is made known to them, and who do not get off the job until a solution of the difficulties has been reached. It is that faculty upon the part of the members of the Society of Automotive Engineers that has placed them in such close relation to the governmental departments in Washington and to the consummation of the war program.

If every member can take home with him from this meeting a realization of this fact and a determination that he will serve—not let George do it, but that he will do the things that come to his hand to do—I believe that we will do more toward making possible the ending of this conflict than any other industrial group in the United States.

We are interested in almost every branch of the war program. We are interested in the production of munitions, of the motor transport, of tanks, of aircraft—almost every conceivable line of work entering into the activities of war are adaptable in some way to the manufacturing organizations of which S. A. E. members are a part. I hope that those of us who are trying to do our bit down in Washington may feel that we have behind us the absolute support and the coordinated brains and activity of the Society of Automotive Engineers, and of this greatest of all the manufacturing industries of this country that it represents.

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Gallup, D. L., Nordyke & Marmon Co., *Indianapolis.*
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Lipman, C. E. L., Lipman Air Appliance Co., *Beloit, Wis.*
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O'Brien, Thomas, Willys-Overland Co., *Toledo, Ohio.*
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Williams, F. B., Sumter Electrical Co., *Chicago.*
Williams, Louis W., Union Drawn Steel Co., *New York.*
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Bell, George, Remy Electric Co., *Detroit.*
Bosmerth, S. B.
Breaker, H. O.
Broegger, I. W.
Brown, E. H., General Aluminum & Brass Mfg. Co., *Detroit.*
Burnett, Robt. S., Society of Automotive Engineers, *New York.*
Carmann, L.
Carter, E. R.
Chapins, Mr., Wright-Martin Aircraft Corp., *New York.*
Childs, H. B., *Flying*, 280 Madison Ave., *New York.*
Cooney, Frank E., lieutenant, Signal Reserve Corps, *Washington.*
Condit, K. H., lieutenant, Signal Corps, *Washington.*
Cradens W. H., Electric Storage Battery Co., *Philadelphia.*
Critchley, J. I., captain, British Mech. Transport, *New York.*
Dail, C. L., Splitdorf Electric Co., *Newark, N. J.*
David, E. J., *Flying*, 280 Madison Ave., *New York.*
Davids, W. C., Chevrolet Company, *New York.*
Dean, E. W., U. S. Bureau of Mines, *Washington.*
Demony, A. W., Timken-Detroit Axle Co., *Detroit.*
DePalma, Ralph, *New York.*
*Dickinson, B. G., United Motor Service Co., *New York.*
Ellis, Geo., *New York.*
Elliott, C. V., General Electric Co., *Schenectady, N. Y.*
Foulmar, C. A.
Fry, W. L.
Giffin, P. G., Signal Corps, *Washington.*
Gordon, H. H., *Washington.*
Gurney, D., Gurney Ball Bearing Co., *Jamestown, N. Y.*
Hagenlocher C. P., Wright Roller Bearing Co., *Philadelphia.*
Hall, Lieutenant, U. S. N.
Harriman, D. F., Wright-Martin Aircraft Corp., *New York.*
Harris, M. B.
Haskin, W. E.
Hawke, C. B., Rich Tool Co., *Detroit.*
Hazard, G. E., Kellogg Mfg. Co., *Rochester, N. Y.*
*Hecox, F. C., captain, Q. M. C., *Washington.*
Heywood, C. E., Society of Automotive Engineers, *New York.*
Hodgkins, M. O.
Holmes, C. W., Motor Compressor Co., *Newark, N. J.*
Hubbard, F. S.
Kelley, E. A.
Kellog, F. H., Electric Storage Battery Co., *Philadelphia.*
Kelsey, H. W.
Kirkpatrick, W. H., *Detroit.*
Lane, D. E.
Little, Thomas, J., Lincoln Motor Co., *Detroit.*
Lumpkin, W. H.
McCarty, C. J.
McCulla, I.
McGinnis, G. E., Chandler Motor Co., *Cleveland.*
McKay, W. E.
McTighe, Arthur D., *Air Service Journal, New York.*

*Applicants for Membership.

Magill, H. L.
Manville, Tracey F.
Margolin, Geo.
Marshall, L. C.
Matthews, J. A.
Mitchell, F. R.
Morgan, E. T., inspector, Signal Corps, *Plainfield, N. J.*
Morris, L. Philip, Morris Engineering Co., *Springfield, Mass.*
Morrow, F. W.
Mulford, Ralph K., Rajah Auto Supply Co., *Bloomfield, N. J.*
Munson, Wm. C., *Detroit.*
Nevins, C. A.
Newton, C. H.
Oberg, E., *Machinery, New York.*
Palmer, M., Aeronautical Society of America, *New York.*
Panier, Alfred.
Peltz, G. M.
Pender, H. E.
Peterson, C. A., General Vehicle Co., *Long Island, N. Y.*
Phelps, Geo. B., Ingalls Ship Forging Co., *New York.*
Pinkerton, F. W., Federal Miniature Lamp Division, *New York.*
Pomilio, A., Turin, Italy.
Post, R. W.
Powell, R. H., The Harley Co., *Springfield, Mass.*
Praether, Jesse A., Signal Corps, *Washington.*
Price, W. T., Price Engine Corp., *New York.*
Ridgway, C. J.
Rorer, J. F.
Rossi, L. M.
Rowland, P. W.
Ruggles, F. W., lieutenant, Signal Corps, *Washington.*
Saitta, P. W.
Sandkuhf, E. H., Price Engine Corp., *New York.*
*Schirmer, J. O., Schirmer Frensdorf Co., *Cleveland.*
Seeley, M. S.
*Sendelbach, E. C., Rech Marbaker Co., *Philadelphia.*
Shattuck, F. E., B. F. Goodrich Co., *Akron, Ohio.*
Shattuck, V. R., Booth Felt Co., *Brooklyn, N. Y.*
Shedinger, W. F.
Sherbondy, E. H., Signal Corps, *Dayton, Ohio.*
*Sherry, R. H., General Motors Co., *Detroit.*
*Simpson, D. S., Palmer-Simpson Corp., *Saranac Lake, N. Y.*
Smith, J. Henry.
Smith, V. E. Armand, lieutenant, Signal Reserve Corps, *Washington.*
Smoot, C. H.
Snook, F. W. B.
Soubner, G. K.
Stengel, lieutenant, U. S. Navy, *Washington.*
Sullivan, M. I.
Tottle, J. C.
Teall, J. E., Morris Engineering Co., *New York.*
Twombly, W. I.
Vezzani, F., lieutenant, Italian Commission, *Washington.*
Watkin, L. M., Jr., Standard Roller Bearing Co., *Philadelphia.*
Whalen, W. E.
White, A. E., captain, Ordnance Department, *Washington.*
Wiler, John C., lieutenant, Signal Corps, *Washington.*
Williams, Ray J., Lincoln Motors Co., *Detroit.*
Winchester, J. F., Standard Oil Co., *Newark, N. J.*
Zouck, G. H.

PRESIDENT CHARLES F. KETTERING

THE OFFICERS OF THE SOCIETY

IN accordance with the amendment to the Constitution adopted last summer, there are now fifteen members of the Council. Instead of one second vice-president, the council now has five, each representing a different phase of automotive engineering. In the following paragraphs a brief outline is given of the career of the men who will guide the work of the Society during the coming year.

Charles F. Kettering

President Kettering and electricity first began to get acquainted with each other something over twenty years ago. Mr. Kettering then became connected with the Star Telephone Company of Ashland County, Ohio. They have been pretty closely associated ever since.

Mr. Kettering was born on a farm near Loudonville, Ohio, considerably less than fifty years ago. He grew up amid the wholesome influences of farm life, and, early in his career, developed a determination to accomplish something worth while.

The district school started him on his way. A term or two at high school and a session of summer normal work fitted him for teaching, and for a few terms he was in charge of the country school near his home.

Then he became connected with the Star Union Telephone Company, in the construction department. He stayed there just long enough to become thoroughly imbued with the idea that electricity was destined to be about the biggest thing in industry, and then started off to the Ohio State University to learn more about it.

He was graduated from the University and then went back to the telephone company and put into practice some of the knowledge he had acquired.

He was still in that position when E. A. Deeds got in touch with him and induced him to come to the National Cash Register Company.

The National Cash Register Company was in need of a little motor to operate its electric cash registers, and Mr. Kettering was selected for the task of designing the motor.

The work he did is still in use practically in its original form on all electrically operated cash registers throughout the country.

He was in charge of one of the invention departments of the National Cash Register Company when the necessity for electrical equipment for automobiles impressed itself upon him.

About seven years ago Mr. Kettering developed his first generator system of ignition, which was adopted by the Cadillac Motor Car Company. The complete system of cranking, lighting and ignition quickly followed, and in the summer of 1911 the first Delco equipped car appeared on the market.

Mr. Kettering is, at present, president of the Dayton Engineering Laboratories Company. He is vice-president of the Domestic Engineering Company, manufacturers of Delco-Light electric lighting and power units for farm use. He is also vice-president and consulting engineer of the Dayton Metal Products Company, the Dayton-Wright Airplane Company, is one of the promoters of the Dayton Engineers' Club, and the Dayton Research Laboratories. He has rendered substantial aid in the "Greater Dayton" movement, and is a good example of what the engineer can accomplish in furthering civic development.

In addition to all these other activities, Mr. Kettering is finding a good deal of time to devote to the interests of the Government in airplane development work, to which cause he has already made some valuable contributions.

Mr. Kettering was elected in 1910 to membership in the Society. In 1913 he served on the Electrical Equipment Division of the Standards Committee. At the 1916 Summer Meeting he delivered an address on the wonders of modern science, illustrated with laboratory apparatus, that was one of the features of the whole meeting.

David Beecroft

First Vice-president Beecroft was born in the seventies at Marnock, Ont., Canada. His business life started in 1893 when he taught a country school for one year, previous to finishing university work at the Barrill Collegiate Institute. This was followed, beginning in the fall of 1895, with a six-year period of school teaching in St. Thomas, Ont., during most of which time he was connected with the editorial department of the St. Thomas daily paper, writing editorials, biographies, and handling other news features.

Leaving St. Thomas in the summer of 1901, he went with the Chicago *Daily News* as an advertising solicitor, remaining until December, 1902. During this period he was also Chicago correspondent for two or three papers.

In December of 1902, on resigning from the Chicago *Daily News*, he took the editorship of the *Automobile Review*, which was until then a monthly automobile publication printed in Chicago. It was at once changed to a weekly, and he continued there for about fifteen months, resigning on March 1, 1904, to take the position of assistant editor of *Motor Age*, where he has been since that time, for two years as assistant editor and, when *Motor Age* was purchased by the Class Journal Company of New York, as editor.

In July of 1911 he took, in addition to the *Motor Age* work, the position of managing editor of *The Automobile*. In November of that year he also became managing editor of *Commercial Vehicle*, and in February of 1914 he took a similar position with *Motor World*.

Since entering the automobile industry he has been particularly active with all contests, has drafted the stock-car rules for the Crown Point Races, held in 1909 in Indiana. He has been closely connected with all road racing in the Chicago zone, having served as referee on all the Elgin Road Races, as well as in a similar capacity for most of the reliability runs from Chicago. He has been on the A. A. A. Contest Board for years.

Mr. Beecroft became a member of the Society in 1911 and has served on the Council during the last two years. He has been a member of the Meetings Committee of the Society for two years, last year serving as chairman.

C. C. Hinkley

Second Vice-president Hinkley (representing motor car engineering) is general manager of the Hinkley Motors Corp., which he organized in May, 1917, to build heavy duty engines.

He was born on July 15, 1883, and graduated from the Chicago Training School in 1901. Entering the employ of the Peerless Motor Car Co., Cleveland, in 1903, he worked successively with the Stearns, Olds and Chalmers companies, in an engineering capacity. After leaving the Olds Motor Works, in 1909, he occupied the position

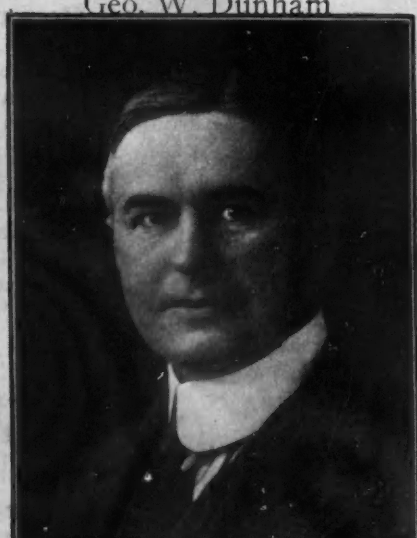

David Beecroft


C. C. Hinkley


Geo. H. Houston


Geo. W. Dunham


Fred Glover


Henry R. Sutphen


H. R. Brate

of chief engineer for the Chalmers Motor Company, holding the latter position for five years. He specialized along design and engineering lines almost exclusively in his connection with the business, his experience covering all phases of the work. A couple of years of his experience were devoted principally toward the production end of the business.

Mr. Hinkley has been active in Society affairs since his election to membership on July 12, 1910, and at present holds the office of chairman of the Detroit Section of the Society. He is also a member of the Engine Division of the Standards Committee.

George H. Houston

Second Vice-president Houston (representing aviation engineering) has spent the last twelve years as a manufacturing executive with different companies. He has been with the Root & Vandervoort Engineering Co., the Moline Knight Automobile Co., the Curtiss Aeroplane Co., and the Wire Wheel Company. He is a member of the firm of Goethals, Jamieson, Houston & Jay, consulting, investigating and managerial engineers, and at present is engaged in directing the development of the aeronautic engine program of the Wright-Martin Aircraft Corp., as active executive head and general manager. Mr. Houston was elected a member of the Society on June 21, 1917.

Henry Randolph Sutphen

Second Vice-president Sutphen (representing marine engineering) was born at Morristown, N. J., May 13, 1875, son of Rev. Dr. Morris Crator and Eleanor (Brush) Sutphen. He was educated at public and private schools. At 18 he entered the employ of the Electric Launch Co., Bayonne, N. J., now the Elco Works, Electric Boat Co., and since then has been continuously associated with that company and its successors. He occupied successively various positions until he became chief designer, engineer and vice-president of the company. He was also general manager until February, 1917.

Mr. Sutphen is the inventor of numerous patented devices and appliances connected with electrical and gasoline boat building. He has designed and supervised the construction of many pleasure boats of different types, having specialized on sea-going craft of late years.

The most notable achievement of Mr. Sutphen was the design and construction of 550 so-called "submarine chasers" for the British Admiralty. They set a new record for rapid construction of sea-going boats of a novel type, the total number (550) having been built in 488 days. Their efficiency and sea-worthiness have been demonstrated by actual service in the present world war.

In April, 1917, Mr. Sutphen presented to the United States Shipping Board, Emergency Fleet Corporation, the plan of building standardized steel merchant ships of structural steel. This idea has been developed to date to the point of standardizing details for constructing and equipping 5000-ton steel cargo ships; the hulls are so designed that structural steel can be employed in the place of the usual ship steel. The design has been so modified that nearly 85 per cent of the entire hull can be fabricated in structural bridge and tank shops of the country. The material will be assembled at the Newark (N. J.) Bay Shipyard, which will accommodate 28 ships, and a maximum production of one ship every two days is anticipated; the contract calls for 150 5000-ton steel cargo ships.

Mr. Sutphen is a member of the Chamber of Commerce, Engineers Club of New York, New York Yacht Club, Seawanhaka-Corinthian Yacht Club and the Automobile Club of America. He is a full member of the Society of Naval Architects and Marine Engineers and vice-president of the National Association of Engine and Boat Manufacturers. On Feb. 1, 1917, he was elected to membership in the Society and was soon made chairman of the Marine Division of the Standards Committee. At the 1917 Semi-Annual Meeting Mr. Sutphen delivered a paper entitled Building Submarine Chasers by Standardized Methods.

Fred Glover

Second Vice-president Glover (representing tractor engineering) took a scientific course at the University of Minnesota and was then in charge of a 10,000-acre farm at Glover, N. D. He left to become one of the incorporators of the Gas Traction Co. He was general manager of that company until 1912 when it was taken over by the Emerson-Brantingham Co., of which Mr. Glover was vice-president from 1912 until a few weeks ago. He has recently been commissioned a major in the Ordnance Department, specializing in the design and manufacture of tanks. He was one of the former members of the Society of Tractor Engineers, which is now part of the Society of Automotive Engineers. Major Glover was one of the first members of the Tractor Division of the S. A. E. Standards Committee and has taken an active part in carrying on the work of the Minneapolis Section of the Society. On Feb. 1, 1917, he was elected a member.

H. R. Brate

Second Vice-president Brate was born July 11, 1882, in Sanfordville, N. Y. His early schooling was received at Palmer Institute-Starkey Seminary, Lakemont, N. Y. At the age of seventeen he entered business school and for several years afterward was in commercial activities. Among the organizations with which he has been connected are the Fairbanks Company at Pittsburgh and the Bryne-Kingston Company, Kokomo, Ind. In the former he was in the gas engine department and in the latter he was for several years a carbureter expert on tractors and gas engines. At the same time he was also connected with the Kokomo Electric Company.

Since 1912 Mr. Brate has been secretary of the National Gas Engine Association. During this period he has written a large number of articles on gas engines and kindred subjects. His book, "Farm Gas Engines," has been used as a text in several state agricultural colleges.

Charles B. Whittelsey

Treasurer Whittelsey has been connected with the Hartford Rubber Works Co. since 1901, at that time as purchasing agent. In 1905 he was made assistant to the general manager, in 1906 superintendent, in 1911 secretary and factory manager, in 1915 vice-president and factory manager, and in 1916 president and factory manager. He was president of the Hartford Chamber of Commerce in 1914 and last year was president of the Hartford County Manufacturers' Association.

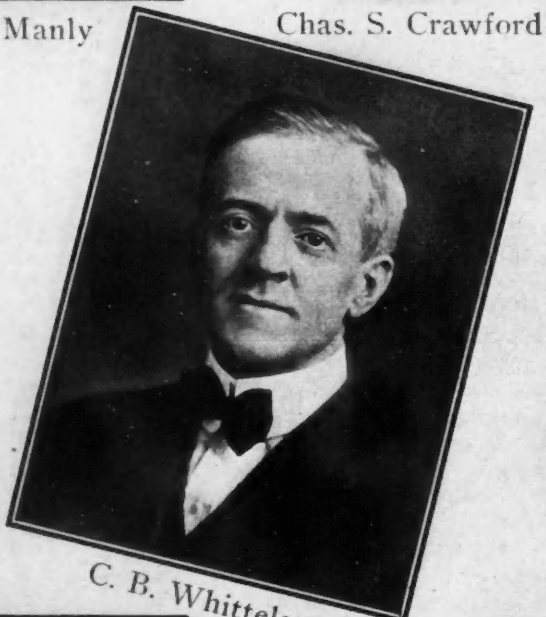
Mr. Whittelsey was elected an Associate Member of the Society in 1910 and was transferred to Member grade the next year. He was made a Life Member in 1916. Since the formation of the Standards Committee of the Society he has been a member practically all the time, serving on the Pleasure Car Wheels and the Truck Standards Division, and now being a member of the Tire and Rim Division. He was a member of the Council of the Society during 1912 and 1913.

J. V. Whitbeck

Chas. M. Manly

Chas. S. Crawford

Coker F. Clarkson



C. B. Whittelsey

C. W. McKinley

H. L. Horning

B. B. Bachman

At the Annual Meeting, 1912, he delivered a paper on Solid Motor Tires, and at the 1915 Annual Meeting presented a paper entitled The Pros and Cons of Tire Inflation.

Charles S. Crawford

Councilor Crawford has held the position of assistant general manager and chief engineer of the Premier Motor Corp. since last October, having been associate engineer of that company prior to that time. He was born in Indianapolis, Ind., April 3, 1883. From 1893 to 1897 he attended grade schools in St. Louis, Mo., and spent Saturdays and vacations serving apprenticeship in foundry work, patternmaking, blacksmithing and machine shop practice in the Carondolet Foundry Co., of which his father was superintendent.

In 1897 he returned to Indianapolis and graduated from the grade schools there. During 1898 he operated both tapping and milling machines in the machine shop of the Waverly Bicycle Company. He returned to St. Louis in the fall of 1898 to take an engineering course in the St. Louis Manual Training School of Washington University, graduating in the spring of 1902 and winning an advanced engineering-course scholarship in Washington University. The summers from 1899 to 1901 were spent in shop work at the Carondolet Foundry. In January, 1903, he left Washington University and returned to Indianapolis, where he was employed in the pump repair department of the Dean Pump Works. Starting early in 1904, he spent nine months with the Big Four Railroad Company, of Indianapolis, in the engineering department and in the actual installation of electric light equipment and in charge of locomotive inspection on twelve Atlantic-type locomotives built at Dunkirk, N. Y. Two months were spent at the Cerealine Mills of Indianapolis, making machinery installation plans, and three months at the Link-Belt Company in charge of the tool room with tool drafting experience.

From 1904 to 1906, Mr. Crawford served as chief draftsman on automobile gas engine and carbureter design at the Speed Changing Pulley Company, Indianapolis. During a portion of the latter year he served as draftsman in the experimental department of the Lozier Motor Works, Plattsburg, N. Y., under John Perrin. From 1907 to the spring of 1909 he was chief engineer of the Speed Changing Pulley Co., on engine, carbureter and automobile chassis design. From that time to the spring of 1910 he was chief engineer of the Cole Motor Car Co., Indianapolis, being their original engineer.

During the summer and fall of 1910 he was purchasing agent for the Empire Motor Car Co., Indianapolis; also chief engineer and factory manager of the Westcott Motor Car Co., Richmond, Ind. During the years 1911-12 he served as chief engineer, factory manager and assistant to the president of Cole Motor Car Co. From that time to February, 1916, he was chief engineer and assistant to the president of this company, making his present connection at the latter date.

Mr. Crawford was elected a member Dec. 22, 1911, and is a member of the Electrical Equipment Division of the Standards Committee. He was chairman of the Indiana Section and is now vice-chairman. In 1916 he delivered a paper before the Indiana Section on Eight-Cylinder Engine Characteristics.

Charles M. Manly

Councilor Manly has been intimately associated with the field of mechanical flight since the days of Langley's first experiments.

Born at Staunton, Va., April 24, 1876, he received his early primary and academic education in South Carolina. He was graduated from Furman University (of which his father, Dr. Chas. Manly, was president), Greenville, S. C., in 1896, with the degree of master of mathematics and mechanical philosophy (M.M.P.). He then took mechanical and electrical engineering courses at Cornell University, graduating therefrom in 1898 with the degree of mechanical engineer.

When, in the spring of 1896, Professor Langley, secretary of the Smithsonian Institution, applied to Dr. R. H. Thurston to recommend some engineer to take charge of the work which he was just then undertaking for the War Department in the construction of a man-carrying airplane, Mr. Manly was recommended by Doctor Thurston and took charge of this work under Doctor Langley's direction on June 1, 1898. He not only had entire charge of the building of the airplane itself, but personally invented, designed, and constructed the 52-hp. five-cylinder gasoline engine, which was used on this large machine, the construction of this engine being completed in 1902. It weighed 125 lb., exclusive of cooling water, radiator, and tanks, or at the rate of 2.2 lb. per horsepower for the 52 hp., which it developed for 10 hr. continuously with a water absorption dynamometer. This was the first aviation engine in the world, as well as the first steel cylinder aviation engine.

He also had charge of all the research work that Dr. Langley carried on in the development of the airplane, including the first systematic tests ever made in determining the laws of the aerial screw propeller and the tests on the supporting power of curved surfaces and equilibrium control. Mr. Manly personally piloted the large Langley airplane during the tests made of it in 1903, on Oct. 7, and Dec. 8, when it was in each case so damaged by catching on the launching gear that it was impossible to get a fair test of its flying ability when it did get into the air.

Owing to the storm of ridicule and criticism heaped on Doctor Langley by the public press, as well as on the floors of Congress, it was impossible to secure further funds, either from the War Department or from private individuals for continuing the work beyond the last test made on Dec. 8, 1903, so that in 1904 the work on the machine at the Smithsonian Institution had to be temporarily discontinued.

From that time he devoted his time to developing some of his own inventions in power transmission, moving to New York in July, 1905, where he organized the Manly Drive Co. of which he was vice-president and chief engineer. The two Argentine battleships, "Rivadavia" and "Moreno," which were completed about three years ago by the Bethlehem Steel Co., were equipped with 60 hydraulic speed gears, known as "Manly drives," for controlling the turrets and pointing the guns. These "drives" are also being used on lift bridges and motor trucks, where complete variability of speed control is desired. He has taken out some forty patents relating to power transmission, engines and automobiles.

From June to September, 1915, he was consulting engineer to the British War Office, in connection with airplanes being built in this country, especially superintending the construction of the large 500-hp. twin-engine biplanes, built at the Toronto factory of the Curtiss Aeroplane Company.

From September, 1915, to the present date he has been consulting engineer to the Curtiss Aeroplane & Motor Corp., Buffalo, devoting his attention during the past 15 months especially to the duties of chief inspection

engineer. He was elected a Member of the Society April 20, 1914, is a member of the American Society of Mechanical Engineers, was second vice-president last year of the Society, member of the Cosmos Club of Washington, and the Aero Club of America. He is chairman of the Aeronautic Section of the Standards Committee of the Society, member of the International Aircraft Standards Boards, and has just been appointed one of the two representatives of the S. A. E. to the International Aircraft Standards Conference to be held in London.

Last year he delivered a paper entitled, A History of Aviation, before the Buffalo Section.

J. V. Whitbeck

Councilor Whitbeck has served successively the H. H. Franklin Mfg. Co. (1904 to 1906), the Olds Motor Works (1906 to 1907), E. R. Thomas (1907 to 1908), the Lozier Motor Car Co. (1908 to 1912). During the next year he was in business for himself as consulting engineer in Detroit and has been chief engineer of the Chandler Motor Car Co. from 1913 up to the present time. In 1912 he was elected a Member of the Society.

B. B. Bachman

Councilor Bachman was born Oct. 4, 1886, educated at grammar school, night school and under a private tutor, and started his business experience in 1900 as a tracer. The next ten years were spent as tracer, detailer and designer with the Enterprise Manufacturing Co. of Philadelphia, the Falkenau, Sinclair Machine Tool Co., Philadelphia, and the Autocar Co. of Ardmore, Pa. His entire automobile experience has been with the latter company, which was manufacturer of passenger vehicles until 1912 and of commercial vehicles from 1907 to date. Starting with this company in February, 1905, he became assistant engineer in 1909 and engineer in 1914.

He was elected a Junior in the Society in 1910 and was transferred to Member grade in 1912. He is an Associate Member of the American Society of Mechanical Engineers, and a member of The Engineers' Club of Philadelphia. He is a charter member of the Pennsylvania Section, S. A. E., and was its first secretary. He has been identified with the work of the Truck Standards Division of the Standards Committee since 1911, and was elected to the Council in 1916. As a member of the Truck Standards Division he participated in the formulation of the specifications for military trucks for the Quartermaster Department, and since August, 1917, has been engaged at irregular intervals in the design of Class B and Class A Military Trucks. In the design of the Class A Military Truck, he was chairman of the committee on design.

At the 1913 Annual Meeting Mr. Bachman presented a paper entitled Comparative Results with Solid and Pneumatic Tires on Light Commercial Vehicles, and at the 1914 Annual Meeting gave a paper entitled Double-Reduction Live Axle.

Harry L. Horning

Councilor Horning secured his early training in the modern classical course in Carroll College Academy and the scientific course at Carroll College, both at Waukesha, Wis. In 1901 and 1902 he was in the chemical laboratory and operating department of the Milwaukee Gas Light Co., and later served for two years in the steam engineering department of the Crane Company. From 1904 to 1906 he was head of the mechanical engineering department of the Modern Steel Structural Co., his most important work at that time being the construction and mechanical operation of the Duluth aerial bridge, one of three such structures in the world.

In 1906 he established the Waukesha Motor Co., and has served as its chief engineer and general manager since that time.

Mr. Horning is a member of the American Society of Mechanical Engineers, and of the Association for the Advancement of Science. He was elected a member of the S. A. E. in 1910 and was particularly active in forming the Society of Automotive Engineers through his connection with the Society of Tractor Engineers and the American Gas Engine Association.

Mr. Horning is now chairman of the Automotive Products Section of the War Industries Board, Council of National Defense. He served as chairman of the Design Committee of Engineers that laid out the engine for the Class B and AA military trucks, is now in his second year on the Council, was the first chairman of the Tractor Division of the S. A. E. Standards Committee, and was a member of the first Oil and Fuel Committee established by the Council of the Society.

Truck and Tractor Engines was the subject of a paper he presented in 1916 at a Mid-West Section meeting. At the 1917 Annual Meeting he presented a paper on The Ultimate Type of Tractor Engine and at the last Semi-Annual Meeting gave a paper on The Farm Tractor as Related to the Food Problem.

Charles W. McKinley

Councilor McKinley was born in Toledo, Ohio, Nov. 16, 1888, and secured his early education there in the public schools and Scott Polytechnic Institute, continuing the study of mechanical engineering in Sibley College, Cornell University, specializing in gas engineering.

He started work as an apprentice in the Etna Machine Works, Toledo, Ohio, first as a patternmaker and later as a draftsman. Later he became designer for the F. Bissell Electric Co., and during 1906-7 engine designer with the Pope Motor Car Co. He was engineer of the Plymouth Motor Truck Co. during 1908 and assistant chief engineer of the Willys-Overland Co. during 1909-12. He held a similar position with the Michigan Motor Car Co. for the following two years. In 1913 he became engineer in charge of the Willys-Overland Co. and is now consulting engineer attached to the Washington office of that company.

From 1914 to date he has been chairman of the Springs Division of the Standards Committee, cooperating with the Quartermaster Corps in development of the standard army truck. He has been a member of the Council from 1916 to date, was chairman of the Membership Committee in 1917 and was a member of the Lock Washer and Ball and Roller Bearing Divisions of the Standards Committee.

George W. Dunham

Past-president Dunham secured his early practical training at Cleveland and in 1901 helped to organize the American Motor Carriage Co., holding the position of chief engineer. In 1904 he became assistant engineer to Past-president Howard E. Coffin at the Olds Motor Works and was advanced to chief engineer of that company in 1906, leaving in 1909 to become chief engineer and factory manager of the Hudson Motor Car Co. The next year he was made vice-president in charge of engineering at the Chalmers Motor Co. In 1915 he became a consulting engineer in Detroit, specializing on automotive design and development. Recently Mr. Dunham

has been made vice-president of the Molitor Co. of Jersey City.

He was elected a member of the Society in 1908 and has been active in Society work since that time. For several years he was a member of the Aluminum Copper Alloys Division of the Standards Committee and also belonged to the Motor Testing Division. He has been chairman of the Detroit Section, chairman of the Meetings Committee of the Society and served as president during last year.

Standardization of Drawings is the title of a paper presented at the Annual Meeting in 1913. At the Kansas City Tractor Meeting, February, 1917, he spoke on The Standardization Work of the S. A. E., and at the Fremont, Neb., Tractor Meeting, Aug., 1917, he spoke on The Future of the Farm Tractor Industry.

Coker F. Clarkson

Secretary and General Manager Clarkson was born in Des Moines, Iowa, 1870, and graduated from Phillips Exeter Academy in 1888. From 1889 to 1890 he was in Government service in the Post Office Department. He graduated from Harvard College in 1894, pursuing post-graduate work there for the next two years. He was next engaged in connection with the installation of an underground telephone system in Philadelphia for two years, after which he went to New York and spent the time from 1898 to 1905 in work on technical, legal, patent, laboratory, and automobile subjects. From 1905 to 1910 he was connected with the Association of Licensed Automobile Manufacturers, as secretary of its Mechanical Branch, publicity manager and assistant general manager. During this time he was the editor of the Handbook of Gasoline Automobiles and of the Mechanical Branch Bulletins sent out by the A. L. A. M. He also prepared the weekly digest of current technical literature that went to all the members of the Mechanical Branch.

From 1910 up to the present time Mr. Clarkson has been secretary and general manager first of the Society of Automobile Engineers and then of the Society of Automotive Engineers when the latter was formed. Mr. Clarkson is now directing the activities of the Society from its Washington office, where he has found it necessary to spend all his time on account of the many Government war activities in which the Society is interested. He has served on a number of official and semi-official Government committees, this service starting with membership on the Motor Transport Committee, the Automotive Transport Committee, and now the Automotive Products Section of the War Industries Board, Council of National Defense. He is a member of the International Aircraft Standards Board.

THE NAVAL CONSULTING BOARD

The annual report of the Secretary of the Navy for 1917 contains several references to the work of the Naval Consulting Board. The S. A. E. is represented on the Board by four members; Howard E. Coffin and A. L. Riker represent the former Society of Automobile Engineers, while Bion J. Arnold and Elmer A. Sperry represent the former American Society of Aeronautical Engineers. Both these, of course, are now part of this Society. Below are extracts from the report:

"The Navy has fully and gratefully availed itself of the organizations and facilities provided by the War Industries Board, the Council of National Defense, including the National Research Council, the Aircraft Production Board, and the able and helpful Naval Consulting Board, which was originally organized for naval purposes.

* * *

"The Naval Consulting Board has been found very useful, not only in assisting in the solution of military problems but in dealing with the immense flood of inventions and ideas submitted to the department from the country at large. It is true that a majority of these are not found to be of practical value, but it is a fact that practically all of them are submitted with the patriotic motive of helping win the war, and the department has felt that they are all entitled to serious and appreciative consideration.

* * *

"Valuable assistance has been rendered merchant shipping by the board's activities. Through its initiative, counsel and work the United States Shipping Board formed its ship-protection committee, taking over the study of the protection of merchant ships; and to this committee was detailed one of the Consulting Board's most experienced members qualified in shipbuilding and with sea experience. In this field the board's work has resulted in materially reducing the shipping risk, with a consequent lowering of marine insurance rates.

"Not the least result of its work has been the stimulation of interest in the problems brought up by the war, throughout the country by the general invitation to submit ideas for investigation. Early in the calendar year 1917 this interest manifested itself in the receipt of thousands of ideas weekly, and to care for this the department's connecting office has been greatly enlarged, the office of the board in New York has been organized on a working basis with a large force, and the whole movement has received the approval and hearty assistance of the great national engineering societies. The president of the board, Thomas A. Edison, has been giving his entire time to the work of the board in the service of his country, and has called to his assistance a capable staff who are working diligently upon naval problems.

"With war conditions increasing the need for labor and building materials, it was believed to be a wise policy to defer for a time the building of the new experimental and research laboratory. Such experiments as have been warranted have been made in private laboratories generously offered and at the Bureau of Standards. The need for this establishment, however, is more clearly shown than ever, and its support is urgently advised.

"The valuable results obtained by the work of this board are of too confidential a nature to make them the subject of a public document. The members have given freely of their time and scientific ability to the service of the nation and have earned the gratitude of all who know their unselfish and patriotic service. I wish to express my sense of obligation for the cheerful cooperation, wise counsel, loyal devotion, and personal sacrifice which have characterized the membership of the board of distinguished civilians who responded, long before the war was declared, to the selective draft with all the enthusiasm and efficiency of youthful volunteers."

Types of Military Airplanes

By Col. V. E. Clark* (*Member of the Society*)

Annual Meeting Paper

THE military types of airplanes, as influenced by the military functions and as influencing the design of the engine that goes into the airplanes, will be the subject of this brief discussion.

The Allies have run to more types than the enemy. One of the main reasons for this is that the Allies have listened more to the demands of their fliers, who have exerted much influence on plane and engine design. Thereby, standardized production has been sacrificed to individual requirements.

It will be America's part in the aircraft program to select those types that best lend themselves to big production—to look ahead six or twelve months in an endeavor to anticipate the advance requirements, and then design those types in such a way that they can be built on a large scale. Standardization means fewer types—greater numbers of machines. We must select perhaps five or six types, develop them, and *produce* them by the thousands. We should select for standardization from the following types:

(1) Airplanes of Observation.
(2) Airplanes of Combat and Pursuit.
(3) Airplanes of Destruction and Harassment.
(4) Special Types.

None of these types is new. All can be developed to a far greater degree of efficiency than those now being used. Each type has a different function. Airplanes of observation must aid the army on the ground in successfully performing its operations. Those of combat and pursuit must prevent enemy aircraft from doing damage in any way. Those of destruction and harassment will inflict direct damage on the enemy. With special types we have little concern. Of chief concern to me—to the Aircraft Board—to America—in fact, to the world, are those planes that will inflict direct damage on the enemy. They are the bombing machines, upon which depends a substantial part of the measure of victory, of that I am convinced.

The need for these being recognized and vital, and the hour of their initial production being at hand, I shall confine my remarks to a limited discussion of their possibilities.

Bombing operations provide practically all the real damage that it is, at present, possible for an airplane to inflict upon the enemy. In comparison to these the slight damage caused by bringing down his airplanes, each containing one or two men only, or shooting up his trenches or truck trains, is negligible.

The enemy should be harassed continually from the air. Two classes of bombers must be employed—day bombers and night bombers.

Use of Day Bombers

Under present conditions along the Western front *material* damage must be done at night. Day bombers will be used solely for the moral effect of inflicting perpetual unrest except in a few special cases when vulnerable objectives are difficult to locate at night.

The primary military functions of the day bomber are:

(1) To bomb important points, such as small objects difficult to find by night, headquarters, small ammunition "dumps," small storehouses containing munitions or supplies, small railway junctions, and small aerodromes.

(2) To bomb such communities as is considered desirable, especially factories and factory towns.

(3) To conduct long-range reconnaissance, strategical reconnaissance, reconnaissance by staff officers, or with camera.

(4) To do special photographic work so far beyond the lines as to necessitate great altitude, demanding a camera of great focal length and therefore great size and weight.

The primary requirements for this airplane in order that it can effectively perform its military functions are:

(1) Ability to protect itself effectively against all hostile aircraft, which demands good speed at altitude, strong climbing ability, powerful and reliable armament, and a satisfactory degree of "handiness."

(2) Reliable powerplant.

(3) Powerplant with good fuel efficiency.

(4) Capacity for as many bombs as will not prohibit satisfactory provisions for protecting itself against enemy aircraft as discussed above. I believe that, at the present time, it is not an economic proposition to send a trained pilot and a trained "bombardier" a great distance beyond the enemy's line unless at least 600 lb. of bombs are carried.

(5) Effective provision for accurate sighting of and dropping bombs.

(6) Ceiling should be high enough so that the machine stands a good chance of escaping detection as it crosses the line.

(7) Muffler for the exhaust capable of being cut in and off at the will of the pilot.

(8) Two or three machine guns, one firing through the propeller disk and one or two with all-around fire, with good field to the rear.

(9) Provision to carry two men.

(10) Reliable compass.

Typical airplanes of the day bomber type are the DeHaviland-9 (British), with 300-hp. FIAT engine, the S. I. A. 7-B (Italian), with 200-hp. FIAT engine, the S. I. A. 9-B (Italian), with 600-hp. FIAT engine, and the Breguet 14-B2 (French), with 300-hp. Renault engine. The German Gotha twin-engine machine (two 260-hp. Mercedes engines), while rather too slow and too unhandy for the purpose, has done some service bombing by day over London.

Night Bombers

The type designed for bombing by night, in my opinion, must be depended on to inflict real material damage upon the enemy. I believe that the consistent employment of these machines in large numbers on every good moonlight night to bomb Germany's munition factories, factory towns, important railway junctions, large munition depots, the bridges across the Rhine, the Kiel Canal, important docks, submarine bases, and certain cities, would end the war in a shorter period of time than is possible by any other means.

*Airplane Engineering Division, Signal Corps, U. S. Army.

The primary requirements for these machines in order that they can effectively perform their functions are:

(1) Great bomb capacity.

(2) Reliable powerplant.

(3) Powerplant with good fuel efficiency.

(4) Proper degree of stability and controllability to permit a pilot of ordinary ability, and a limited amount of training to fly and land at night.

(5) Effective provision for accurate sighting for, and dropping of bombs.

(6) Accurate compass and other instruments necessary for navigation by night, with provision for reading conveniently at night.

(7) Provision for carrying two to five men. Probably the best practice is a crew of three, a chief pilot, a "bombardier," and one man to man a gun forward or to the rear, as may be necessary, and to act as relief pilot.

The load of bombs that can be carried will depend upon the total power available at an altitude of 10,000 ft., and upon the distance of the objective (which will regulate the initial fuel supply). The ratio of total weight of airplane, with full initial load, to the total power available should be small enough to permit a ceiling of at least 11,500 ft., starting with full load. The power plant will be divided into two or possibly three units. Suppose that two U. S. A. twelve-cylinder engines be installed; if no device is incorporated to maintain the power constant with change in altitude, the total power available at 10,000-ft. altitude should be about 450 horsepower. Suppose that the objective lies 155 miles beyond the lines, a bomb load of between 2000 and 2700 lb. can be carried, and the necessary initial ceiling obtained, provided the general design of the airplane be good.

Limiting Weight

The total weight of the airplane in pounds with full initial load should not be more than 22 times the number of horsepower available at 10,000 ft. The total weight should not be more than 5.63 lb. per square foot. The machine should have possible horizontal speed, at an altitude of 10,000 ft. or not less than 85 miles per hour. Starting with full load the airplane should be capable of climbing to an altitude of 10,000 ft. in not more than 27 minutes. For every 16 miles increase in radius necessary to reach the objective, 100 lb. of bombs is sacrificed.

Typical airplanes of the night bomber type are the Caproni triplane (Italian) with three 273-hp. Isotta-Fraschini engines; the Handley-Paige (British) with 320-hp. Sunbeam engines; and the Caproni biplane with three 210-hp. S. P. A. engines. The German Gotha, with two 260-hp. Mercedes engines, is typical.

The number of night-bombing airplanes built and supplied should depend solely upon the number of pilots available for this work. A far lower degree of flying skill is required to pilot a large slow night bomber than for a fast fighting machine, although more mature judgment is necessary.

As a matter of fact, the number built and supplied will, in all probability, eventually depend upon steamship space for transatlantic transportation and upon the hangar space at the aerodromes in France, and possibly upon the appropriation available.

Air Raids With Bombs

Consider, for example, a fleet of several hundred of night-bombing airplanes, each carrying a ton and a half of bombs, flying from large aerodromes located say 25 miles to the rear of the line. The fleet penetrates to Essen, for instance. Each machine locates its objective and drops ten 160-lb. bombs of the high-explosive type on the factories and forty 25-lb. bombs filled with poisonous gas, and twenty-four 25-lb. bombs of the incendiary type throughout the factory town, and returns home.

In the existing phase of the present war were our night-bombing airplanes of sufficient numerical strength it would be no longer a matter of individual and isolated raids on selected places at which the maximum of injury could be inflicted, but rather a continuous and unrelenting attack on every point of strategical importance.

Depots of every kind in the rear of the enemy's lines would cease to exist; rolling stock and mechanical transport would be destroyed; no bridge would be allowed to stand for twenty-four hours; railway junctions would be subject to continuous bombardment, and the lines of railway and the roads themselves broken up nightly by giant bombs to such an extent as to baffle all attempts to maintain or restore communication.

In this manner a virtually impossible zone would be located in the rear of the enemy defenses, a zone varying from 100 to 200 miles in width. As soon as this condition has been brought about, the position of the defending force must be considered as precarious, and eventually impossible. The defense will be strangled from the uncertainty and lack of supplies of all kinds. Ultimately retreat will become impossible. The defending force will find itself in a state of siege under the worst possible conditions. Its position will be in the form of an extended line along which the forces of all arms will be definitely immobile, for the lateral communications will suffer no less than the lines from the rear. In short, a reign of terror would exist. Such a condition presents all the elements conducive to complete and irreparable disaster.

Every one here, I think, will realize that even consistent bombing of factory towns would end the war surely and quickly.

Reasons Behind the Liberty Aviation Engine

By MAJOR JESSE G. VINCENT* (*Member of the Society*)

ANNUAL MEETING PAPER

LAST spring the Government had before it the problem of deciding on an aircraft program. We heard at that time and we still hear that we should take the best engines available abroad and manufacture them in this country. The French and English engineers agreed that there was no engine then being built in this country that would be of any value at the front. They told us that an engine weighing about two pounds per horsepower was required, and that although such engines were not then a reality they were in process of development, and it was hoped that they would be built within a year.

In other words, last spring it was impossible to select an engine from abroad because the manufacturers there did not then have a type with which they were themselves satisfied. They were getting along the best they could with what they had, so it was finally decided to take all the best features embodied in the engines of both the Allies and the Germans and combine them into a composite model having no experimental features. It was desired to combine all the benefits of the experimental work done by the Allies and at the same time have the fewest possible number of types, a manufacturing method followed by the Germans.

The original scheme embodied the manufacture of a number of engines with interchangeable parts. The cylinders were to be varied from four to twelve, possibly using more later if it seemed desirable. At first it was decided to build an eight-cylinder engine of about 150 hp., but before that was completed we were asked to provide a twelve-cylinder engine giving over 300 hp., because more power was necessary.

We must remember that there was no engine in this country developing enough power to satisfy the requirements at the front. It was necessary therefore to provide the entire manufacturing facilities for one or more high-power aircraft engines. If ten or fifteen factories in this country had been asked to design engines of from 350 to 400 hp., at least ten or fifteen different kinds of engines would have been the result. Moreover, it would have been impossible for all the designers to have before them the latest information that we had available. It was decided therefore that it was absolutely necessary to design a completely new engine, one for which the drawings and specifications would be prepared by the Government, so that they could be handed to the manufacturers to produce the engines in quantity.

I want to acknowledge the hearty cooperation of the automobile engineers and manufacturers in doing the work. It was only on June 4 that Major Hall and I were ordered to produce ten sample engines. We had laid out at Washington just about what the design was to be. We then went back to Detroit and engaged a large force of draftsmen to prepare the rough drawings. These were sent out through the country and the first engine was produced in twenty-one days. The patterns and die for the crankshaft and everything else was produced in that time.

In designing the engine we took it unit by unit and considered first what would be the best design and second what would be the best manufacturing construction. We took the cylinders, the valve-operating mechanism, the crankcase construction, the crankshaft, the ignition, and handled them in this way.

The building of the twelve-cylinder engine of course was simple after the eight-cylinder had been finished, because we used practically the same parts except for the crankshaft and crankcase.

When the twelve-cylinder engine was finished, it was given a 50-hr. test; this was accomplished without making any changes and without making a single adjustment during the run. The engine was not operated at the maximum horsepower during the run because it was not designed to be run at such power on the ground. Since that time, however, we have found that it will run wide open an indefinite length of time on the ground. We have also found that by making a few minor changes it would stand over 400 hp. continuously in field service. It is designed for fighting machines intended to fly at altitudes of thousands of feet, and weighs about two pounds per horsepower.

When the sample engines were being built the Aircraft Production Board and the Signal Corps were arranging for facilities so that the engine could be manufactured in quantities. The equipment for manufacturing the steel cylinders is an example of the production methods. These cylinders are manufactured from tubes, and by a clever arrangement the end that is closed in and the small fissure that results from the closure of the end comes just where the port is bored out, so that there is no bad metal there.

The production of the Liberty engine will not only be of great benefit during the war, but it will also do the whole automotive industry a great deal of good after the war. The engineers of the Society have been cooperating for years and, I believe, work together better than the members of any other engineering society in the world. Our factories have also cooperated to a large extent, but the work now going on in the automobile factories producing these engines is bringing them together to a marked degree. This applies not only to the plants making the engines, but also to the parts companies.

If a number of different aircraft engines had been designed in different factories, it would not have been possible to secure this cooperation. Each man would naturally have tried to make his own engine the best. The most important thing is the fact that with the standardized engine we get the benefit of everybody's cooperation on one article, and we can make that engine a great deal better than if any one company continued to make it for a year.

At present we have nothing but twelve-cylinder engines in production, and do not believe that anything

*Airplane Engineering Division, Signal Corps, U. S. Army.

else will be in production during the war, because we want all the power that can be used efficiently.

The Discussion

(The discussion following the remarks made by Colonel Clark, Major Vincent and Mr. Crane consisted merely of questions regarding the operating possibilities and construction of the Liberty engine. The answers by Major Vincent are given below substantially in complete form.)

The cruising radius of the machines in which the Liberty engine will be used is entirely a matter of plane design and the load to be carried. The twelve-cylinder engine when placed in a small, fast machine will give a considerable cruising radius, provided the load carried is not great. On the other hand, two or more of the Liberty engines placed in a large machine with a heavy load will either decrease the power of the engines or lower the speed. The radius could easily be as great as 600 miles, that is 300 miles out and 300 miles back.

A number of problems have been discussed in connection with the ignition. The feeling on the other side of the water is that with the increased number of cylinders and the increased number of engine revolutions, the magneto is unquestionably the best. But we must have two sparks to a cylinder and we must have those sparks in such a way that they can be obtained separately. The whole design is a compromise, and weight is one thing on which we don't want to compromise too much. I believe that the ignition system on the Liberty engine is at least as good as anything that can be designed for it at present.

We will manufacture some engines for the system now in use. In the meantime we will try out anybody's system that looks at all good. I will say that no other system that has been offered to us has been as light, combined with reliability, as the one now in use.

The four-valve construction has been tried on a Mercedes engine and was immediately abandoned. Four valves are much harder to cool than two and should not be used until the limit is reached with one valve. Until a lift of 1/4 in. of the clear diameter is used, the valve is not really being operated efficiently. It would be foolish to use four valves in an engine that was not more than 4 1/2-in. bore by 7 1/2-in. stroke.

There is no reason why the Liberty engine cannot be operated satisfactorily at low speed, the slowest useful speed of the Liberty engine for aviation being 1200 r.p.m. It has no unusual valve timing. The exhaust valve opens 52 deg. early and the inlet closes 45 deg. late.

The present ignition system weighs 29 lb., this including the battery. The test made of the Liberty engine on Pike's Peak showed that power was gained up to a compression ratio of 6 to 1, but that the same engine when brought down to the surface of the earth operated poorly.

Fuel is fed by pressure as in the ordinary method. Auxiliary tanks are provided, these to be used in case of emergency. The lubricating system is of the pressure type. A double-deck pump is used with three gears in the top deck, thus making two suction pumps. The oil is drawn out of the rear crankcase and from the front into a separate case. We have followed the system used by the Rolls-Royce, and well known on the other side, of using a dry sump case, pumping all the oil into a little tank and then pumping it back underneath. Originally the connecting-rods were lubricated by scuppers on the crankshaft which caught the oil that was thrown off. That method was extremely economical, but with it a cold engine could not be started and full power secured. Between 1200 and 1300 r.p.m. there is a noticeable vibration in the operation of the engine, depending to a certain extent on the propeller design. The block angle of 45 deg. has seemed to offset the ordinary calculated period of vibration, which comes at a higher or lower point than it would if the angle were 60 deg.

The new Liberty engine is said to be 50 hp. more powerful than the Rolls-Royce and at the same time at least 150 lb. lighter in weight. The valves are set at angles of 30 deg. The radiator capacity is from ten to twelve gallons.

The Liberty engine originally weighed 786 lb., but some 15 lb. have been added by slightly increasing the weight of three or four parts, thus bringing the total up to about 800 lb. It has developed 400 hp. at 625 r.p.m. and of course more power can be secured by running at higher speed. The speed is limited, however, because we cannot get an efficient propeller speed much above 1600 r.p.m.

The best French engines give between 200 and 250 hp. and weigh about 520 lb., these being of the geared type.

The geared engine is best for some types of work and the direct-drive for other types, but the latter engine is the most reliable, which is wanted, of course, above everything else. The manufacture will be concentrated at first on direct-driven engines, although investigations will be continued as to the possibilities of the geared type.

Two compression ratios are used at present for the Liberty engine. In the Navy engines the compression ratio is 5 to 1 and in the Army engines 5.4 to 1, or something under 18 per cent. The low compression is best for Navy work, which consists largely of flying at altitudes of about 5000 ft. or less. It is desired to fly with a wide-open throttle most of the time so that the Navy engine should run well near the earth's surface. On the other hand the Army engine is used for altitudes of around 10,000 ft. or higher. The larger ratio is necessary therefore so that too much power will not be lost in the air. It is believed that with the steel cylinder construction, which makes for satisfactory cooling, a still higher compression can be used. It is possible to run the engine up to as high as 6 to 1 compression ratio.

The steel cylinders are arranged so that the cooling water can be brought up close to the spark-plugs. The compression pressures have not yet been carried extremely high in the Liberty engine so that spark-plug trouble, as ordinarily known in aviation engines, has not been experienced.

Use of Engines

The Liberty engine in production will be used mostly for fighting work, inasmuch as other satisfactory engines are being built in this country for the training work, and these will be continued in production. The only training planes in which Liberty engines will be used will perhaps be in a few fighting machines in the schools for the final training of pilots.

The airplanes in use at the front are seldom worn out. The only ones worn out are possibly those used at the training camps. When those at the front go out of service it is usually due to an accident of some sort. The average life of a combat machine is about two months, and of the observation machine used in the Army something like three months. The light bombers probably have a much longer life.

Good facilities are now available at Dayton to carry on experimental testing, and it is planned to carry out a great deal of research work in the air, something that it was almost impossible to do in this country heretofore.

A good deal of time has been wasted in designing self-starters. A self-starter is not desired on the plane for combat work because the weight can be used to better advantage in the form of bombs or some other useful things. It is impossible to stop the engine after leaving the ground, so a self-starter is unnecessary. The Navy machines will have self-starters. Whether these are to be air-starters or electric-starters will be worked out later. There is no advantage in having self-starters in the ordinary single-seater or double-seater machines because there are always plenty of men on the ground to start them.

Discussion by H. M. Crane*

It was necessary to build an American engine not because we wanted the eagle to scream, or for patriotic reasons, but for considerations based on practical common sense. If we had imported engines and copied them here, in a year they would have been either American engines or Americanized engines. The only way we could get the industry of the country at work was to use a design that would meet factory ideas in the United States. It is difficult for one engineer to design an engine to be built in another factory in this country, without knowing that factory. It is almost impossible for any foreign engineer to design for an American factory. If we had used an American factory to build a foreign engine, the time for getting it well into production would have been as long as if the engine had been of American design. In addition the production would never have been half what we can expect for an engine designed in this country, with a knowledge of all American factory practice and personnel back of the design.

Early last summer, when I read the newspaper reports that an engine had been designed in three weeks that would lead the world in aviation, I was much startled. When I had the privilege of coming closer to what had been done I found that the newspaper story was only the final printing of the message. What had really occurred was a year or two years of painstaking development, always thinking in terms of American methods of manufacturing, of what has been proved good on the other side. The result was that in a short time—so short a time that it seemed almost impossible—the knowledge thus acquired was transferred to drawings and from drawings transferred to material and to an engine in operation.

For nearly two years, I had some experience with a foreign engine, designed by what I consider the best production engineer abroad. For that reason it has been immensely successful on the other side, yet for this country its manufacture resulted in difficulties that had to be met by adding to our own plant facilities that we should have been able to depend upon in the industry at large.

*Chief Engineer, Wright-Martin Aircraft Corporation.

With the small output we could add these special facilities, but when the Government found it necessary to mobilize the industry as a whole, such a course of action would have been impossible. Instead of our being of real help sooner than most of our Allies expect, the war might be over before the different factories would learn how to do things in the new way. Another difficulty in manufacturing an engine that it is necessary to copy is that we do not know the history of the unsuccessful experiments that have resulted in the finished product available, and as a result the problem is made much harder. The engine may have been developed in a factory in which certain machine tools were available and may even have been built depending on certain foremen who knew how to do their work extremely well.

The Mercedes engine is an illustration of this. A number of attempts have been made to copy it but I do not know of any copy that can nearly be compared with the original in efficiency or usefulness. The manufacturers who finally secured a fine product as a result of copying the Mercedes engine have, in doing so, altered their processes and the design materially. That is undoubtedly what would have happened to us if we had started on a foreign design. The foreign designs most successful today are not inventions; they are not something startlingly different. We must thank the Germans for showing us that an aviation engine can be of the simplest form, and that the simple construction and form is the best, for then reliability and easy production are secured.

The knowledge of that German experience was a help in going ahead in this country. The Liberty engine is the embodiment of the idea of a small number of parts, simplicity of parts, compactness, all of which make for light weight and reliability.

As Major Vincent said, the cooperation that has arisen in developing the Liberty engine is a matter of tremendous importance in the fighting of the war and will be afterwards. It will make many new friends for all of us, and furthermore we will know these friends in a way that we have never known them before. I believe that when we look back after two years all of us will feel that we have a rallying point, a central point in the industry, as this Liberty engine is, and that it will have gone a long way toward increasing the efficiency of the country in fighting and winning the war.

Chassis Design of Class B Motor Trucks

By Cornelius T. Myers* (*Member of the Society*)

Annual Meeting Paper *Illustrated with* Charts

If there is an accomplishment any more representative of the spirit and constant endeavor of the S. A. E. than the design and building of the first Class B Military Motor Truck it does not appear on our horizon at this moment. It represents one culmination of the ideals for which the Society has labored unceasingly, and that it is to be of service to our country at this time is a reward that few of us expected.

In touching on the chassis design the author will put down just a little of the chronology of events leading up to the starting of the work, and will then touch upon a few fundamentals, following with notes as to details.

On June 27, 1917 (the day after the close of the Semi-Annual Meeting of the S. A. E. at Washington), a large number of engineers representing truck builders and component parts makers met in Washington to discuss with Captain Britton, of the Quartermaster General's office, a military motor truck composed of standardized parts. These men divided up into groups, representing engines, axles, transmissions, chassis, etc., and after some discussion it was decided that the job could be done. A tentative layout for the Class A chassis was discussed. A layout for the Class A truck using the parts suggested by the parts makers groups was made and submitted at the next meeting, which was held July 9 and 10 in Columbus. The layout was discussed and a few changes recommended, which were incorporated and submitted July 20 and 21 for the second Columbus meeting.

A layout of the Class B chassis was made and quite fully discussed. The Quartermaster General's office then took over the work, having decided that a truck standardized in all its parts should be designed. A number of the engineers who had been working on the chassis and parts designs were asked to go to Washington and complete the design under the supervision of the Quartermaster General's office. On July 30 these engineers reported in Washington ready to continue the work.

On August 27 the Schedule Committee on Design was organized and divided the work among parts groups, setting September 10 as the day on which the design should be completed. Between July 30 and August 27 much preliminary work was done by the parts builders groups but no progress could be made with the chassis design, as there were differences of opinion among the members of almost every group of parts designers.

Sample Trucks Started

The parts designs were finished on September 10 and within a few days the chassis designs were so far toward completion that arrangements were made to produce two sample trucks. These were completed in an unbelievably short time, and their satisfactory performance began when the paint on the chassis was hardly dry. Driven from Rochester, N. Y., and Lima, Ohio, they arrived in Washington on October 14 and were presented to Gen. Chauncey B. Baker and by him to Secretary of War Newton D. Baker on October 19, which will always be held a red-letter day in the annals of the Society.

*Consulting Engineer, Detroit.

The chassis design was based upon the Quartermaster General's office specifications of May, 1917, which were closely followed. The principal changes were as follows:

	May Spec.	Actual Spec.
Wheelbase limit	156 in.	160½ in.
Weight limit,	8000 lb.	8800 lb. (aprx.)
Rear tires, diameter,	36 in.	40 in.
Type of tires,	demountable	pressed-on
Radiator surface,		
Frontal,	805 sq. in.	590 sq. in.
Total,	32,220 sq. in.	35,000 sq. in.
Tractive factor (high),	0.0775	0.063
Tractive factor (low),	0.338	0.307
Ignition system,	dual	double
Differential,	locking	free acting
Chassis lubrication,	grease or oil cups	mag. oil feed
Gasoline tank,	30-gal. tank 6-gal. reserve	2 16-gal. tanks
Sprags,		added
Permanent stops for springs,		omitted

The following were the guiding factors in designing the Class B chassis; they are set down in the order in which they were given weight. (This tabulation was not official but was observed by the author, acting as chief draftsman on this work, and it was generally followed):

(1) Reliability.
(2) Accessibility.
(3) Weight.
(4) Simplicity and ease of manufacture.
(5) Operating economy.
(6) First cost.

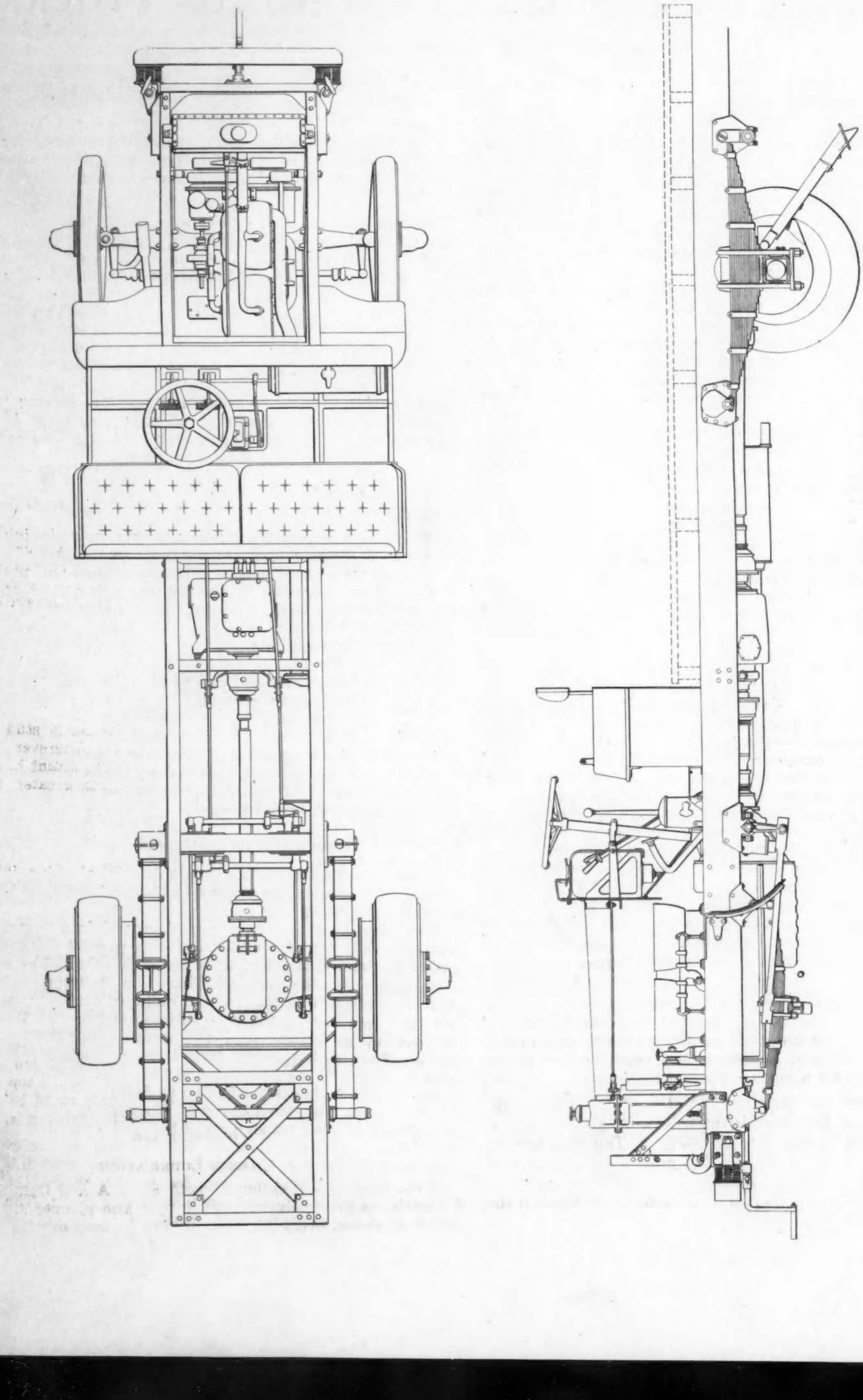
The item of efficiency was more particularly studied and cared for by the parts design groups. Wherever the location or suspension of a part had an important bearing on efficiency it was considered as having greater importance than the second item.

Description of Chassis Units

Possibly as good a way as any to describe the chassis design is to take up the units which enter into its construction, beginning with:

The frame is of open-hearth steel pressed into shape. The side rails are channel section with parallel flanges which are tapered at the front to reduce weight and give greater room for the radiator. There is a heavy pressed steel cross-member in front of the radiator, one between the front brackets of the rear springs, and one at the rear. A lighter pressed steel cross-member supports the rear of the gear-box, while forged cross-members support the front of the gear-box and the front of the engine. The frame is designed to be as flexible as possible without in any way being flimsy or likely to buckle.

The pressed steel frame allowed better distribution of metal than a rolled section, its uniform thickness is of advantage in riveting—there is better assurance of uniformity of metal, and the rounded portion where the flanges meet the web allow large fillets for brackets. The frame is a bit narrower than usual, 34 in. to outside



PLAN AND ELEVATION OF CLASS B UNITED STATES MILITARY TRUCK

edges, in order to allow a maximum turning angle for the front wheels and to save weight in cross-members and support brackets.

The springs are designed to be nearly flat under rated load. The axles are fastened to the middle of both front and rear springs. This permits the assembling of the front springs without fear of deranging the steering-gear linkage, as might take place if the front axle were not in the middle of the springs and the long end of the spring (on a repair job) was put where the short end should be. The spring seats are also reversible and the steering pivots are given a castor action by inclining the whole front spring. This also enabled us to get a good location for the ball on the axle steering arm and to insure a minimum of stress on the steering-gear and connecting-rod due to axle motion.

The rear springs form the driving connection between the rear axle and the frame, a la Hotchkiss. The discussion at Columbus previous to the decision to adopt this type of drive was illuminating, and after all was said the only argument against it was its tendency to throw the rear-wheel brakes out of adjustment if the brake connections were not correctly designed or when the spring under load had a considerable amount of camber. To the author's mind, however, one other point should be given careful attention with Hotchkiss drive—the slip-joint in the drive-shaft at the forward universal joint. Unless the slip-joint is carefully made, thoroughly protected from dirt and properly lubricated, the motion there will result in a serious end-thrust being developed on the universal-joint and the bearings behind it.

By placing the steering-gear behind the rear engine support-arm a long straight connecting-rod was secured. The gear is held by a capped trunnion-bracket and can be readily removed without disturbing the engine or controls. One of the bolts in the gearcase extends through a lug on the bracket and thus relieves the spindle of any bending strains. The column is firmly braced to the dash. The steering-gear case is located so that the clutch can be removed without disturbing the gearcase. The cap for the gearcase carries a lug that supports the clutch and brake pedals, and makes a very clean bit of design at this point where, on the average truck, lifting the floor boards reveals an entanglement of brackets and shafts and nuts that are impossible to adjust without a wrist like a flamingo's neck.

The tires specified were 36 by 5-in. single front and dual rear or 36 by 10-in. single rear. They were to be of the demountable type. After much discussion the change was made to the pressed-on type, saving some 400 lb. in weight and affirming the almost unanimous opinion of the engineers on the job and the tire makers that it was the better type. The evidence from across the water, also, was strongly in favor of the pressed-on type.

The 36-in. rear tires were changed to 40 in., which gave 2 in. more clearance under the rear axle, better adhesion, better rolling on bad ground, lower gasoline consumption, more tire mileage, and an 11 per cent increase in the truck speed for a given engine speed.

The wheelbase, named as 124 in. minimum and 156 in. maximum in the Quartermaster General's office specifications, was increased to be 160½ in. This was deemed advisable in order to keep the proportion of live load on the rear axle below 90 per cent, and at the same time have ample seat-width and a sufficient space between the seat and the steering column.

Mounting of Units

The mounting of the units in the frame was carefully considered from the following standpoints:

(1) Frame flexure.
(2) Accessibility.
(3) Independent assembling and demounting.
(4) Simplicity.

The radiator has two feet which rest on soft pads on each frame rail. The single holding-down bolt in each foot passes through a clearance hole in the rail and a coil spring between the foot and the nut allows the radiator to take its easiest position when the frame distorts. A rod from the flange of the top tank of the radiator to the dash holds the radiator in an approximately vertical position.

The engine also has a three-point mounting. The two rear lugs on the flywheel housing rest in pressed steel pocket brackets rivetted to the frame rails. A vertical bolt passes through each lug bracket, and a heavy spiral spring between the bottom of the bracket and the nut. The bracket is so formed that the engine lug will be held in place even if the bolt is lost. It is lined, so as not to chafe the aluminum lug. The third "point" of the engine support is a cylindrical surface on the timing gear cover around the nose of the crankshaft. This swivels in a forged cross-member which is bolted to brackets on the frame rails. This construction is light, substantial and is easy to dismount when necessary. An odd feature is that the boss leading from the bottom of the radiator to the pump on the engine is jointed by a piece which is fastened to and passes through this cross-member.

The clutch is housed in with the flywheel and the gearshift is mounted on the clutch housing. The hand-brake hand-lever is mounted on the side of the gearshift housing and is (to the author's mind) an objectionable feature, as it subjects light aluminum castings and the stud threads in them to the heavy pull in the brake-rod. This pull can be severe when the rear springs flex violently, for the ratchet on the hand-lever is non-yielding and there is bound to be some relative longitudinal motion between the rear axle and the brake rocker-shaft.

The gear-box suspension is three-point. At the rear of the box two forgings bolted to it carry lugs for horizontal transverse pins which are carried by vertical clevis bolts in a pressed steel cross-member of the frame. The third "point" of suspension is in a forging around the nose on the front of the gearcase. This forging is held in brackets riveted to the frame. The center-line of the main shaft in the gear-box is a little lower than that of the engine. This gives a slight angularity to the front propeller-shaft and also some motion to the universal-joint trunions; it thus drops the gear-box cover below the top of the frame and gives more nearly a straight-line drive from the gear-box to the rear axle.

The design of the dash and the gasoline system, which was considerable of a problem, was solved by locating half the supply of gasoline in a tank on the dash and the rest in a reserve tank under the seat. When this was first suggested a hand air-pump was to be provided, as was also a pipe from the reserve tank to the top of the service tank so that the reserve supply could be readily transferred. At present, however, the transfer is accomplished by means of a bucket or can.

Method of Chassis Lubrication

In the chassis lubrication of both Class A and Class B chassis, as originally laid out, it was also planned to use oil at almost every point—grease to be used only in

the wheel hubs and in the universal-joints. When in Washington last week the author learned that this was not being carried out on the Class B chassis at some points where it could readily be done. On the Class B all the spring bolts, shackle pins and brake rocker-shafts are oil-lubricated by the "magazine system." Wicks convey oil by capillary attraction from pockets of considerable size in the bracket castings to the bearing surfaces. The pockets need to be filled but once a month. Dirt is not fed to the bearing surfaces even if the oil is dirty. The oil feeds only when the truck is in motion. Seepage from the spring bolts follows down the leaves of the springs and keeps them from rusting. The front axle steering-pins are lubricated in a similar manner and the steering connections are designed for small wick oilers. Grease cups have been put on the connecting-rod to lubricate the steering balls, on the starting crank, on the brake spindle of the rear axle and at other points.

Paragraph 30 of the Quartermaster General's office specifications lays particular stress on the "tractive factor" of the truck as a measure of its ability for negotiating heavy grades and bad roads. The formula for "tractive factor" is as follows:

$$^{**}T\ F = \frac{8.4\ n\ b^2 s\ R}{D\ W} \times E_m \times E_t$$

n=number of cylinders in engine.
b=cylinder bore, inches.
s=stroke of cylinder, inches.
R=gear reduction between engine and driving wheels.
D=diameter of driving wheels, inches.
W=total weight moved, pounds.
E_m=efficiency of engine compared with A. L. A. M. (now N. A. C. C.) rating as unity.
E_t=efficiency of transmission system from engine to road.

Since $8.4\ n\ b^2\ s\ E_m$ represents engine torque in pound-inches the formula can be written

$$T\ F = \frac{\text{torque} \times R \times E_t}{\frac{1}{2}\ D\ W}$$

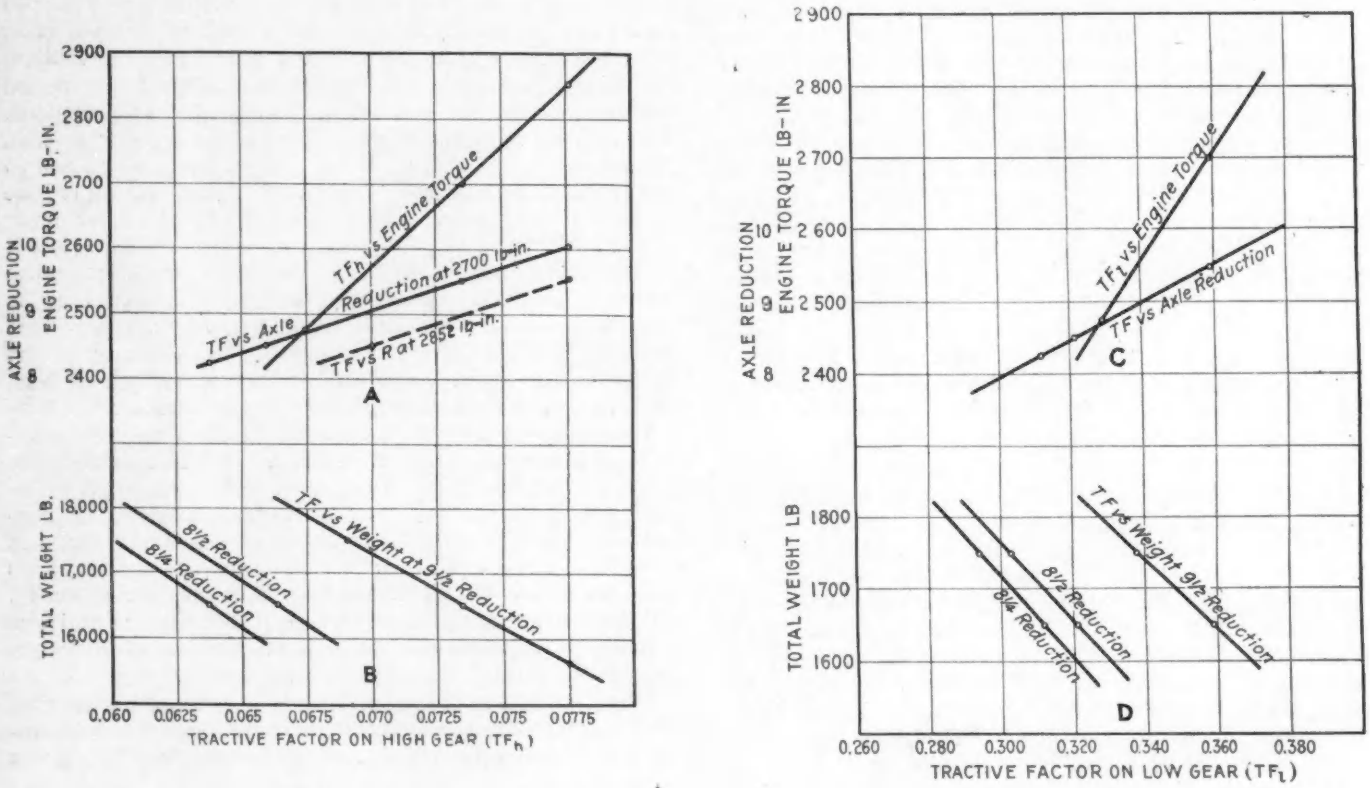
Figs. 1 and 2 represent a study of the specifications for the Class B motor truck on the assumption of its coming within the weight limit of 8000 lb. for the chassis. It was predicted that the 4¾ by 6-in. four-cylinder engine would develop not less than 2700 lb-in. average torque between 600 and 1000 r.p.m. The worm-gear reduction is 9.5; one-half the wheel diameter given in the specifications is 18 in.; the transmission efficiency given in the specifications is 85 per cent; the total weight moved was estimated at about 16,500 lb. From these figures (on high gear)

$$T\ F_h = \frac{2700 \times 9.5 \times 0.85}{18 \times 16{,}500} = 0.0734$$

The low gear reduction in the gear-box itself is 5.93 and the specifications call for a transmission efficiency of 70 per cent. Whence (for low gear)

$$T\ F_l = \frac{2700 \times 5.93 \times 9.5 \times 0.70}{18 \times 16{,}500} = 0.359$$

Deducting a road coefficient of 0.0175 as the rolling resistance over hard roads, these figures indicate that the loaded truck should take a 5½ per cent grade on high gear and a 34 per cent on low gear.



FIGS. 1 AND 2—PERFORMANCE CHARACTERISTICS ON HIGH AND LOW GEAR OF CLASS B TRUCK

**See articles by the author, S. A. E. Transactions 1913, Part I; 1914, Part II; 1916, Part II.

Calculation of Tractive Factors

Diagram A in Fig. 1 shows the "tractive factor" in high gear plotted against a variable engine torque and also against different axle reductions. It shows that to get the "tractive factor" called for in the specifications (0.0775) with the reduction of 9.5 adopted, the engine would have to deliver a torque of 2852 lb-in. On test the first engines developed in the neighborhood of 3000 lb-in. torque. It is safe, therefore, to count on 2700 lb-in. as a production standard. The dotted line shows the $T\ F_h$ available at 2852 lb-in. using different gear reductions.

Diagram *B* shows $T\ F_h$ plotted against total weight (W) at different axle reductions (R) and indicates that to get a $T\ F_h$ of 0.0775 the total weight cannot exceed 15,650 lb., which would call for a chassis weight of 7150 lb. Diagrams *C* and *D*, Fig. 2, show similar data for the "tractive factor" on low gear.

Modifying these results to suit the 40-in. driving tires and the 17,300 lb. weight we get for the truck as completed

$$T\ F_h = 0.063$$
$$T\ F_l = 0.307$$

These diagrams show the vast importance of minimum weight as regards truck performance. This is emphasized for the reason that the main criticism of the truck as a whole could be made on the basis of its weight. The primary reason for this weight lies in the tractive factors specified by the Quartermaster General's office and in the gear-box reduction of 5.93. The secondary reason is that the parts design groups were strongly impressed with the arduous service that the truck would be called upon to perform, and each group played safe in the matter of the size of parts it recommended.

As a commercial possibility the Class B chassis may be questioned on the score of weight, speed, load rating and gasoline economy. Slight modifications, however, should make it the best 5-ton chassis that rolls. There are some details that are not yet fully developed for the service for which this chassis is intended, but these will undoubtedly be cared for and perfected. There is so much good design in the component parts and in the chassis itself that in many ways it will be a criterion for some time to come. To the author's mind, an English officer, after having examined the sample trucks and questioned some of our engineers regarding them, summed up the matter well when standing back and viewing one of them critically, he exclaimed, "Well, she looks a job, she looks a job."

Design of Class B Truck Engine

By A. F. Milbrath* (*Member of the Society*)

Annual Meeting Paper *Illustrated with* Charts

In the early stages of the Military-Truck Design, it was the idea to limit the interchangeability of parts to the complete units, such as engines, axles and transmissions. Several meetings of parts makers were held, with a view of determining the degree to which their regular products could be standardized, so as to make them interchangeable in the chassis.

In the case of the engines, it was found that a standard set of installing dimensions could be determined, which necessitated only slight changes for the various manufacturers. This would have made it possible to replace a damaged unit with one of another make, in case none of the original type was available.

However, the farther this work progressed the more important it was considered by the War Department to have interchangeable, not only complete units, but all of the component parts of the units as well. It is obvious that this plan will greatly reduce the number of parts necessary for maintenance of the trucks at the front. When this decision had been made the engineers of various parts manufacturers were called to Washington to work up suitable designs to meet the requirements of the government.

Torque and Piston Displacement

The division in charge of the engine design was required to develop an engine with a torque output of at least 2800 lb-in., which was necessary to give the tractive factor predetermined for these trucks. An average of the performance of various engines built in the past showed a torque of about 6¾ lb-in. per cubic inch of piston displacement. Using this figure as a basis, the piston displacement of the Class B engine was determined as about 415 cu. in. Possibly the most important consideration in the designing was that of keeping the wearing parts of these engines very large so that adjustments and replacements of parts would be required but seldom.

Stroke and Bore

It was considered desirable to keep the stroke-bore ratio as high as possible, without obtaining too great a total weight of engine or too great a height overall. The length of stroke was therefore the determining factor in determining the stroke-bore ratio. A 6-in. stroke was finally adopted. This with a bore of 4¾ in. gives a piston displacement of 425 cu. in.

Engine Speed and Valve Diameter

The normal speed of these engines was set at 1050 r.p.m., which with the 6-in. stroke gives a piston speed of 1050 ft. per min. The speed of maximum horsepower was also predetermined at about 1500 r.p.m. From past practice it was shown that the maximum horsepower of an engine was developed at a speed at which the theoretical gas velocity through the valves was about 14,000 ft. per min. Assuming an engine speed of 1500 r.p.m., the valve area should therefore be:

$$(4\tfrac{3}{4})^2 \frac{\pi}{4} \times \frac{1500}{14000} \text{ or } 1.9 \text{ sq. in.}$$

This requires a valve 2⅛-in. diameter in the clear, 2⅜-in. outside diameter, 45-deg. seat, with a lift of 11/32 in.

*Engineer, Wisconsin Motor Manufacturing Company.

At the normal engine speed this will give a gas velocity of 160 ft. per sec. through the valve.

Compression Ratio

With the heavier grades of gasoline now in use the compression must be carried somewhat lower than was possible a few years ago, otherwise serious pounding will result in the cylinders. The displacement per cylinder also has some effect on the compression, since a larger cylinder has a smaller wall surface cooling effect per cubic inch of charge than a smaller engine. The past experience of the designers was again called upon, and from this a clearance volume of 24½ to 25 per cent of total volume was determined upon. This clearance will give a compression of about 65 lb. gage at slow cranking speeds.

Connecting-Rod and Piston

The connecting-rod of the military engines as compared with regular practice might be considered of the long type, its length being 13¼ in., or 2.21 times that of the stroke. The standard practice varies from about 2 to 2.2 times the stroke. Both upper and lower bearings are laid out central with the rod. The rod is of the I-beam section and the upper end is bronze-bushed for the piston-pin, while the lower end is of the four-bolt type.

The piston is 6⅛ in. long, with three ¼-in. rings of the conventional type, with 45-deg. saw-cut. The piston-pin is 1⅜ in. diameter and is located 2⅝ in. from the lower end of the piston. A single lock-screw holds the piston-pin in place. This passes through both sides of the piston-pin and piston boss, the lower end of the screw being threaded into the piston boss, while the reduced body size of the screw fits into the upper wall of the piston-pin and boss. The bushing in the upper end of the connecting-rod is 2⅛ in. long, giving an area of 2.92 sq. in. At low engine speeds, when subjected to gas pressures only, this bearing sustains a pressure of 1700 lb. per sq. in. maximum.

At 1500 r.p.m. the greatest pressure due to inertia and gas forces is 1200 lb. per sq. in.

Crankshaft Design

As the crankshaft is the backbone of an engine, considerable thought was given this important part. It is of the conventional three-bearing type. While the governed speed of the engine was to be 1050 r.p.m., it was desired to keep the stresses and bearing pressures low even at 1500 r.p.m. All calculations were therefore made at this higher speed. The stresses considered were three: Those due to gas pressure, to inertia, and to centrifugal forces. Fig. 1 shows these stresses for one position of crankshaft on the power stroke. These forces as affecting the crankpins are given in Fig. 2. The normal gas pressure at beginning of power stroke is assumed to be 280 lb. gage, and the expansion curve to follow the equation $p\ v^{1.3}$ = constant. In the calculation of inertia forces the reciprocating weight was taken at 10 lb., including the piston, which weighs 6¼ lb., and the upper end of rod, with wristpin, weighing 3¾ lb. The centrifugal force is set up by the lower end of the rod with bearing, weighing 5½ lb.

In the diagram the forces acting during the suction stroke are represented by dotted lines, those acting during the compression stroke by dash lines, during the power stroke by solid lines, and during the exhaust by dot-and-dash lines. In laying out these forces it was assumed that the gas pressure during suction and exhaust stroke was equal to that of the atmosphere. The lines representing forces during the lower end of the exhaust stroke are not shown, as they practically coincide with the lines representing the compression forces. It will be noted that the greatest pressure exists at the end of the exhaust or beginning of the suction strokes; also that with the exception of the first part of the expansion stroke all pressures are outward from the center of the crankshaft.

The crankpins of the Class B engine are 2⅜-in. diameter and 3 in. long. Deducting for fillets at each end, this gives a projected area of 6.53 sq. in. The maximum pressure on the pins is 520 lb. per sq. in.; the minimum 160 lb., and the mean 330 lb. At 1050 r.p.m. the centrifugal and inertia forces are: $(1050/1500)^2$, or 49 per cent of the forces at 1500 r.p.m. At this speed the forces due to gas pressure on the expansion stroke predominate. The maximum crankpin load is then 512 lb. per sq. in., while the minimum and mean are somewhat less than one-half the loads at 1500 r.p.m.

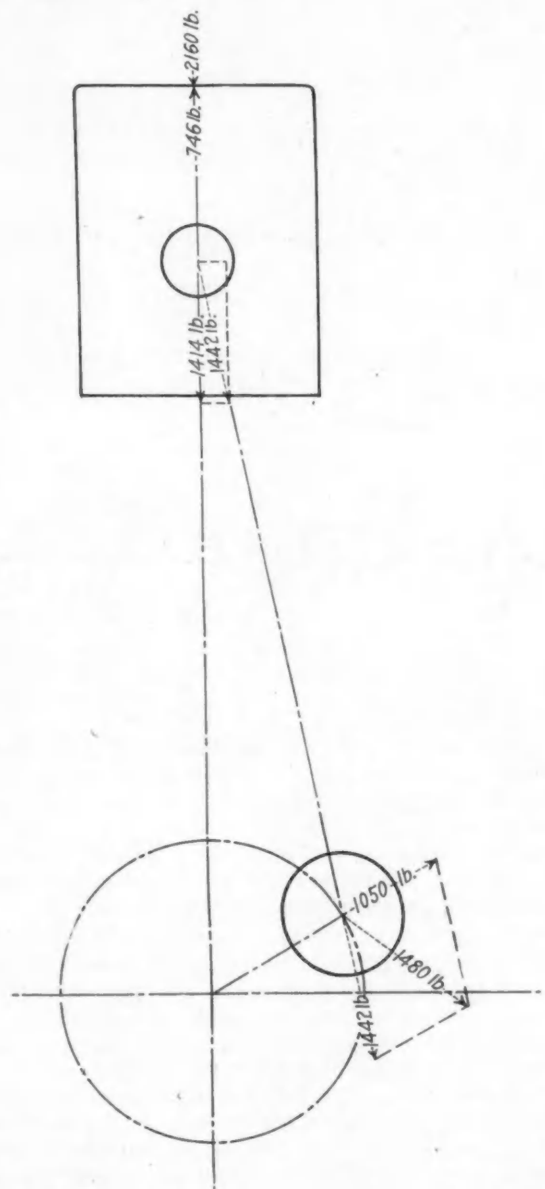


Fig. 1—Stress on One Position of Crankshaft on Power Stroke

In the calculation of main bearing pressures there must be added to the above forces the centrifugal com-

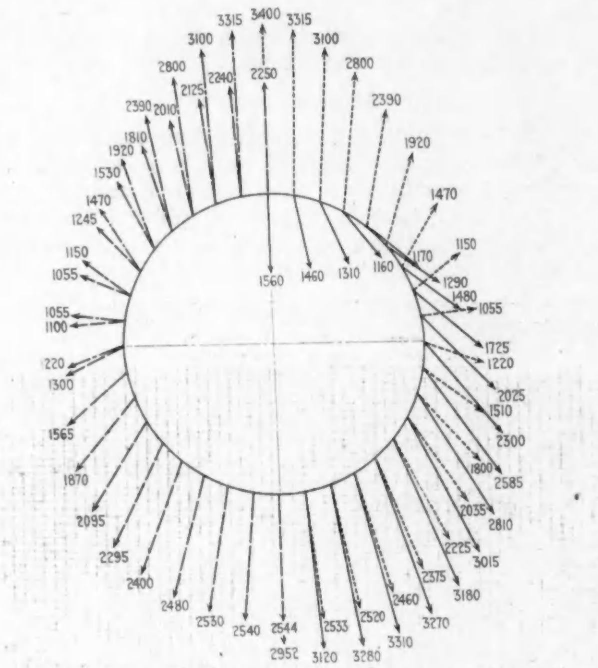


FIG. 2—RESULTANT OF FORCES ACTING ON CRANKPIN

ponent of the short crank-arm and a crankpin. Fig. 3 gives the resultant of the forces acting on the main bearings. These forces are due to gas pressure, inertia and centrifugal forces from one cylinder, one set of reciprocating parts, one crankpin and short crank-arm.

Bearing Pressures

In order to decrease the number of spare parts, only two sizes of bearings are used on the crankshaft. The connecting-rod and front main bearings are interchangeable, likewise the center and rear main bearings, which are 2½ in. diameter and 4 in. long; allowing for fillets, this gives a projected area of 9.375 sq. in. The pressures on the front main bearing (in pounds per square inch) are 727 lb. maximum, 32 lb. minimum and 509 lb. mean. The center bearing takes the load from two cranks at the same time. When No. 2 cylinder is on the suction stroke, No. 3 is on the power stroke; when No. 2 is on compression, No. 3 is exhausting, and vice versa. The forces from the two must therefore be combined to obtain the pressure on the center bearing. The result (in pounds per square inch) is a pressure of 903 lb. maximum, 485 lb. minimum and 695 lb. mean.

The rear bearing carries about the same load as the front, plus the weight of the flywheel. The flywheel load is almost negligible, however, as it amounts to less than 15 lb. per sq. in. The maximum pressure on the rear main bearing is 492 lb. per sq. in., the minimum 38 lb. and the mean 355 lb. At 1050 r.p.m. the main bearing pressures are also considerably less than at 1500 r.p.m.

As might be expected, owing to the liberal dimensions of crankpins and main bearings, the fiber stresses in the shaft are low. The crank-arms are of heavy design also, in proportion to the pins, so that the maximum stresses, due to combined torsion and bending, are less than 10,000 lb. per sq. in.

Cylinder Construction

The cylinders are cast in pairs, of the L-type, with valves on the right-hand side. The heads are removable and held in place by 13½-in. studs. The valve stems are inclosed by pressed-steel cover-plates. The water-jackets are of very liberal thickness, tapering from ½ in. below to 1¼ in. above. The spark-plugs are screwed directly into the cylinder-heads and are entirely surrounded by water. Cooling water enters the jackets at the lowest point and leaves the heads at the highest point. Thus no drain cocks are necessary, the entire cooling system draining from one point.

Crankcase and Flywheel

The crankcase is cast of aluminum and is very deep and well ribbed. The parting line between upper and lower half is 3 in. below the center-line of the crankshaft.

The flywheel is inclosed in a No. 3 S. A. E. bell housing. Three-point suspension is employed, two arms cast onto the bell housing and a trunnion bearing on the front gear-cover. Shouldered studs with castle nuts are used for attaching the cylinders. Provision is made for the mounting of electric starters, and generators are mounted as regular equipment. The front gear-cover is of cast iron and is well ribbed on account of its acting as forward support. The lower half of the crankcase forms the oil-pan, and it entirely incloses the oil-pump.

Camshaft and Gears

The camshaft is drop forged with integral cams and flange for mounting the driving gear. The cams are 1⅜-in. diameter, with 11/32-in. lift. The timing is as follows: Inlet opens 15 deg. past top center and closes 35 deg. past lower center; exhaust opens 45 deg. before lower center and closes 5 deg. past top center. The camshaft bearings are a trifle larger than the cams, so that the shaft can be easily withdrawn.

The timing gears are 1¼-in. wide, with 9 pitch-teeth cut on an angle of 27¼ deg. The drive is from the crankshaft gear through an idler to the camshaft and water-pump gears, and from the camshaft to the generator-drive gear.

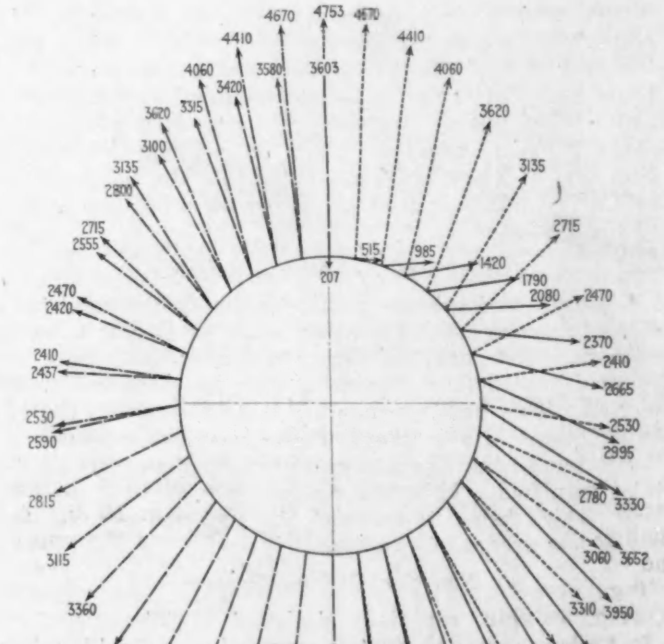


FIG. 3—RESULTANT OF FORCES ACTING ON MAIN BEARING

The valve tappers are hollow, $1\frac{1}{8}$-in. diameter, of the roller type. They carry adjusting screws 1-in. diameter, also bored hollow.

Oiling System

The oiling system is of the force-feed type, embodying a gear-type circulating-pump. No oil pipes are used, the oil being forced through a passage drilled in the pump body to a header extending the full length of the crankcase, then through drilled passages to the main bearings. Grooves are provided in the main bearings, which are in constant communication with the oil holes drilled through the crankshaft to the connecting-rods. Oil tubes on the connecting-rods lead oil to the piston-pins. A relief valve set for 10-lb. pressure is fitted to the front end of the main oil header, and the overflow from this valve lubricates the gears.

The oil-pan or lower half of the crankcase is so formed that the oil will drain toward the center of the sump, even though the engine is inclined, as in climbing or descending a hill.

The oil drains from the crank chamber through a spout into a settling chamber, where any water or mud settles, and can be drained off from time to time. As the oil rises in the settling chamber it finally overflows the top into a large strainer, which completely surrounds the settling chamber. Through this strainer the oil flows by gravity into the sump proper.

The oil-pump is supported from the upper crankcase and extends down into the sump. Another strainer surrounds the oil-pump, so the oil is thoroughly cleaned. No parts whatever outside of the settling chamber and large strainer are attached to the lower half of the crankcase, so this can be dropped by taking out the bolts, without interfering with anything else. No oil float of any kind is used, but a graduated test rod is fitted, which can be withdrawn to ascertain the amount of oil in the engine.

Methods of Ignition

Two entirely independent systems of ignition are incorporated; a high tension magneto, which is driven from the rear end of the water-pump shaft, and a combined timer and distributor with coil mounted at the forward end of the engine, on the left-hand side, and driven through helical gears from the water-pump drive-shaft. Two sets of spark-plugs are fitted into the heads of the cylinders, and the engine can be run on either one or both of the systems.

Inlet and Exhaust Manifolds

The inlet and exhaust manifolds are on the right-hand side of the engine. A heating chamber is cast integral with the inlet manifold near the center and where the vertical branch from the carbureter joins the horizontal section. This heating chamber bolts directly to the exhaust manifold at a point where an opening is cast in the latter, so that the hot gases can circulate around the inlet manifold. This forms a hot spot about 4 or 5 in. long, which helps to vaporize the fuel and permits the use of low grades of gasoline.

Fan for Cooling System

A 22-in. fan, especially designed for these engines after a long series of tests, is mounted on a rigid bracket, bolted to the crankcase. The fan is provided with a vertical adjustment for taking up the slack in the belt. This, however, will be seldom necessary, as a 2-in. belt and large pulleys are fitted, which will drive the fan when set up with only a slight tension.

Engine Governor

An entirely inclosed governor, driven from the forward end of the generator shaft, is built into the engine. The centrifugal members of this governor consist of four 1-in. steel balls, held in place by a spider. The governor revolves at about one and one-half times engine speed. The thrust from the balls is 34 lb.

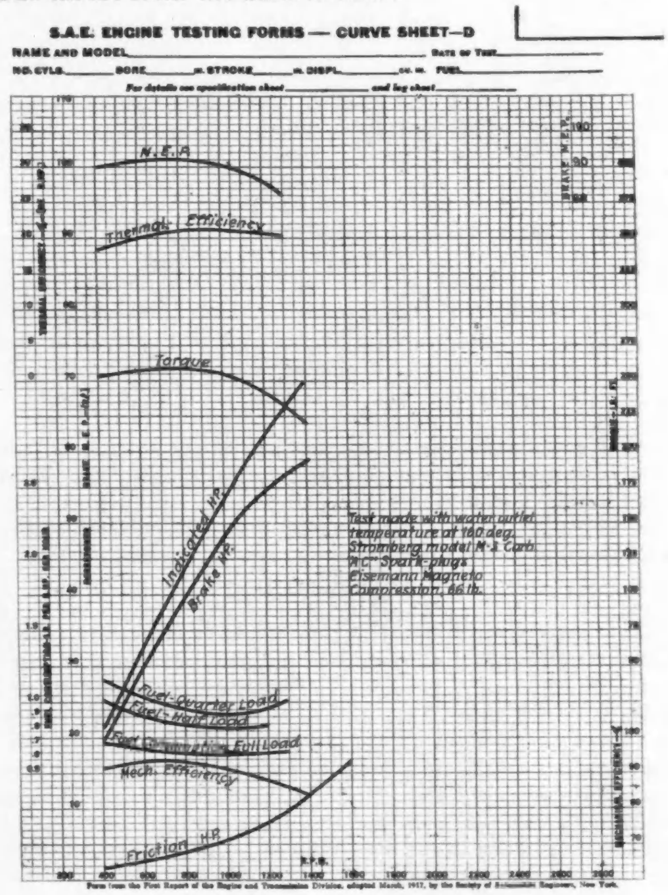


FIG. 4—PERFORMANCE CURVES FOR CLASS B TRUCK ENGINE

On their outward movement, these balls travel against the face of a 45-deg. disk, which also gives the balls a longitudinal movement against a collar free to slide on the governor shaft. The collar has a movement of 3/16-in., which is transmitted through a vertical lever, multiplying the movement threefold. A link with ball joints connects the upper end of the lever with a throttle spindle in the inlet manifold. A spring is fitted to the vertical lever, and an adjustment with a seal is provided.

Performance Curves

Fig. 4 gives the performance curves of one of the first engines built. The maximum torque is developed at 800 r.p.m., and is equal to 258 lb-ft., or 3096 lb-in.

With a piston displacement of 425 cu. in. this gives a torque of 3096/425, or 7.27 lb-in. per cu. in. piston displacement. Fuel consumption is given for quarter, half and full load. At 1550 r.p.m. the maximum horsepower would be developed.

Transmissions for the Class B Truck

By A. W. Copland* (*Member of the Society*)

Annual Meeting Paper *Illustrated with* Charts

THE first meeting of the newly formed Transmission Division of the S. A. E. Standards Committee was held May 2 and 3, 1917, in Cleveland. Some two weeks before this time the Motor Transport Board of the War Department had issued standard specifications for Class A and Class B gasoline motor trucks in the preparation of which the Truck Division of the S. A. E. Standards Committee assisted.

The first business taken up by the new Division was a study of the standard specifications as they directly or indirectly influenced the transmission and clutch design. Some minor changes in the specifications relating to transmissions and clutches were suggested. These were accepted by the Government and incorporated in the later edition of the specifications.

At this time the plan was to accept any commercial engine, transmission, and axle that would come within the specifications and use them in trucks that would measure up to the requirements. However, the design of the fastening points and connections for each major unit was to be standardized so that each unit would be interchangeable with any other unit of its class. The Transmission Division took up this work with great earnestness and held several meetings during May and June.

Nearly every transmission maker in the country submitted at least one design and some manufacturers presented a new design at every meeting. It was found necessary to make changes in the fastening points of every transmission then in production which was submitted for consideration; in most cases the gears and countershaft were the only parts not changed. One maker insisted on having the size of holes in the rear supporting-arms of his transmission made the standard, declaring it was the only thing on the outside of his design that had been left to him. Real constructive work was accomplished by the free discussion and friendly criticism of each other's designs.

Engineering Discussion

The following incident will illustrate the practical value of these frank discussions: Mr. A. remarks: We have never had an entirely satisfactory thrust bearing and throwout device for our clutches; we attempt to lubricate the thrust bearing by delivering oil from the transmission through a passage in the shank of the drive-gear. This passage was connected by radial holes with the thrust bearing. If we make these holes large enough to insure sufficient lubrication at all times, occasionally the flow will be so excessive as to drain the transmission. We have tried a felt damper in the drive-gear but this has proved only partly successful because so many different kinds of transmission lubricant are used. Now, I have noticed that Mr. B. does not provide any means for lubricating the thrust bearing, but uses a type of thrust bearing quite different from ours. As he has been using this bearing for a long time we have decided to adopt Mr. B.'s type of thrust bearing.

Mr. B. squirms a bit and then confesses he has not been entirely free from thrust-bearing trouble and even has thought seriously of trying the type Mr. A. was about to abandon. Everyone was thus brought into the discussion, and it was decided to make a careful study of the problems involved in the design of the clutch throwout. This was done, and eventually led to a new arrangement of the parts which insures uniform distribution of pressure on the bearing and permits lubrication from the outside with a minimum of trouble.

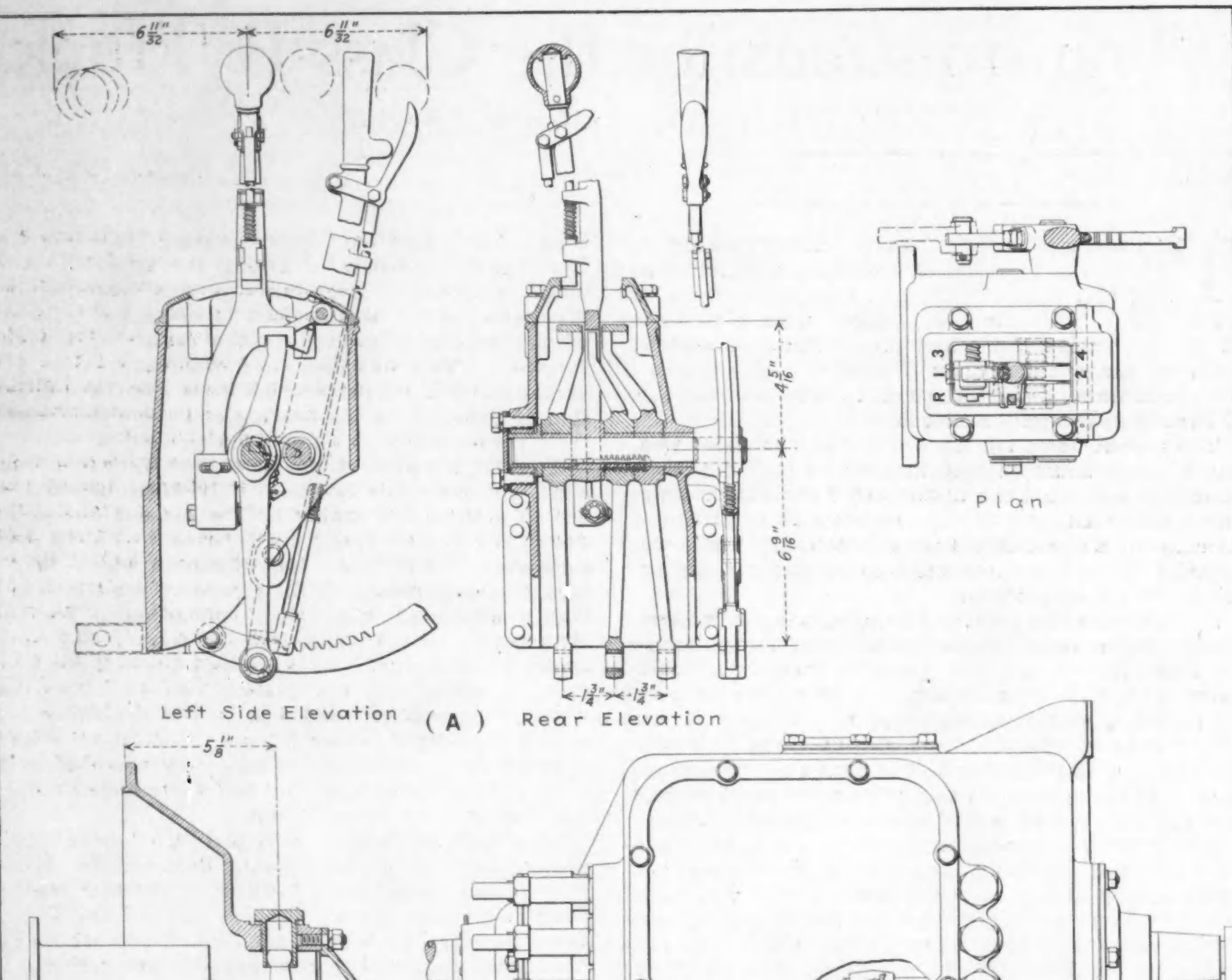
A gratifying amount of constructive work was brought about by these confessions. Patriotism impelled each one to disclose everything he knew about transmission design and to state freely his experience with the devices suggested. Those with improvements which they expected to incorporate in their product sometime in the future submitted ideas with commendable frankness. With nearly all the transmission makers of the country working together with such a splendid spirit, great progress was made, and at a meeting held June 2 in Washington, four makers decided to join in designing a new transmission for the Class A truck. Several other makers signified their willingness to adopt the new design later if they were called upon by the Government to make transmissions for Class A trucks.

As so much preliminary work had been done in previous meetings and by the engineering departments of transmission makers the main features of the new transmission design were quickly decided on, and the Ball and Roller Bearings Division of the S. A. E. Standards Committee was requested to recommend bearing sizes. The sizes of ball bearings it recommended were considerably larger than used in commercial practice, but the bearing engineers insisted that for military use they could not approve smaller sizes. Stress diagrams were made for all bearings, gears and shafts. At the meeting held July 20 in Columbus a tentative design was submitted. At this time drawings of most of the details had been made but at this historical Columbus meeting the Government told us it would adopt one design only for each detail part of the A and B Trucks "to the last screw, bolt and nut." The transmission makers had progressed so far in this direction that it was an unbroken continuance of their work to consider the transmission and clutch for the Class B truck, which the Government stated was needed first.

Details of Transmission

The Government asked for volunteers among S. A. E. members to go to Washington and design two sizes of military trucks. The desired number quickly volunteered and were called to Washington July 30, when the different groups commenced at once to consider their particular problems. The B transmission is of the amidship type with four speeds forward and one reverse. The main shaft and countershaft are located in a horizontal plane with the idler gear-shaft above and to the left looking from the rear forward. The horizontal type was adopted in order to get the ground clearance specified, 18 in. below the transmission at a point midway between the front and rear wheels.

*President, Detroit Gear & Machine Company.



DETAILS OF TRANSMISSION AND CONTROL FOR CLASS B TRUCK

The transmission weighs about 230 lb. The case is of aluminum. The front is supported by a 6-in. trunnion within which is mounted the outer drive-gear bearing. The rear is supported by two steel forgings bolted and doweled to the back of the case. The fact that the mainshaft and countershaft are in a horizontal plane, and that the idler gear is placed above minimizes the depth below the mainshaft.

The gears are 5-7 pitch, 6 in. from center to center of main shaft and countershaft. The width of gears increases from $1\frac{1}{4}$ to $1\frac{1}{2}$ in. from the constant mesh gears to the low, according to the tooth pressure developed and the work it is expected each speed will be called upon to do.

Values of Speed Ratios

The speed ratios are 5.93 to 1 on first and reverse speeds, 3.23 to 1 on second, 1.76 to 1 on third, and direct on fourth speed. As the rear axle reduction is 9.5 to 1 this gives a total reduction of 56.335 on first and reverse.

It is common practice in transmission design to have the reduction considerably greater on reverse than on first. The ordinary four-speed transmission arrangement with a ratio of 5.93 on first would have one of 6.78 on reverse. A total reduction of 56.335 was considered ample to secure the tractive factor desired in the Class B truck under almost any road conditions, so it was decided to make the ratio on reverse speed in the transmission the same as on low; all working parts to the rear of the transmission can thus be made lighter than would have been required if the usual practice had been carried out, of having the reduction reverse greater than on low speed. The countershaft first-speed gear is forged integral with the countershaft. The other countershaft gears are held with a single key.

The reverse idler gears are made from an integral forging. The shifter slot is between the gears. All gears are made from forgings. The mainshaft is $2\frac{1}{4}$-in. S. A. E. six-spline, ground all over except where threaded. A clearance is provided over the splines in the keyways of gears, the working fit being between the ground bore of the gear and the small diameter of shaft between the splines.

All shafts are specified alloy steel equal to $3\frac{1}{2}$ per cent nickel in physical properties, properly case-hardened. Gears may be made of alloy steel equal in physical properties to $3\frac{1}{2}$ per cent nickel. The steel may be high carbon properly heat-treated or low carbon properly case-hardened. All the gears are now being made of $3\frac{1}{2}$ per cent nickel steel, low carbon case-hardened.

The lower part of the mesh lock-plungers are wedge shape. Instead of leaving a thin straight end, the end is machined concave and rounded off. This design gives greater wearing surface than the cone-pointed plunger and the concave end prevents the plunger from turning around. There is no interlock in the transmission but a positive interlock is provided in the control set. The control set is a rocking-lever type.

Annular ball bearings are used for drive-gear shank, mainshaft case bearing and countershaft. The mainshaft spigot-bearing is of the solid roller type running directly on the pilot on the end of the mainshaft and in the end of the drive gear. Plain phosphorus bronze bearings are used for the idler gears. The drive-gear shank terminates in a $1\frac{1}{2}$-in. S. A. E. taper and the mainshaft in a $1\frac{3}{4}$-in. S. A. E. taper.

Current Practice Followed

Although the several units of the Class B truck were designed by separate groups, the different groups kept in close touch with each other and the result is a truck of balanced design. The Class B transmission is in no sense a compromise design. Each part of the design had practically the unanimous approval of the transmission engineers on the job, and in most cases represents successful current practice. It is confidently expected to give a good account of itself under the most trying conditions on the battle front. Throughout the whole design S. A. E. Standards were used just as fully as they were available.

The speed-change H-plate is the S. A. E. recommended practice. No rocker-arms are used in the transmission. The shifter forks are fixed to the shifter rods by hardened screws having special taper ends. The shifter forks are as short as the diameter of gears will allow. The arrangement is such that the shifter rod nearest to the idler gear is the one used for reverse. Grooves of 90-deg V-shape are used for the shifter-rod notches.

Design of Military Truck Axles

By G. W. Carlson* (*Member of the Society*)

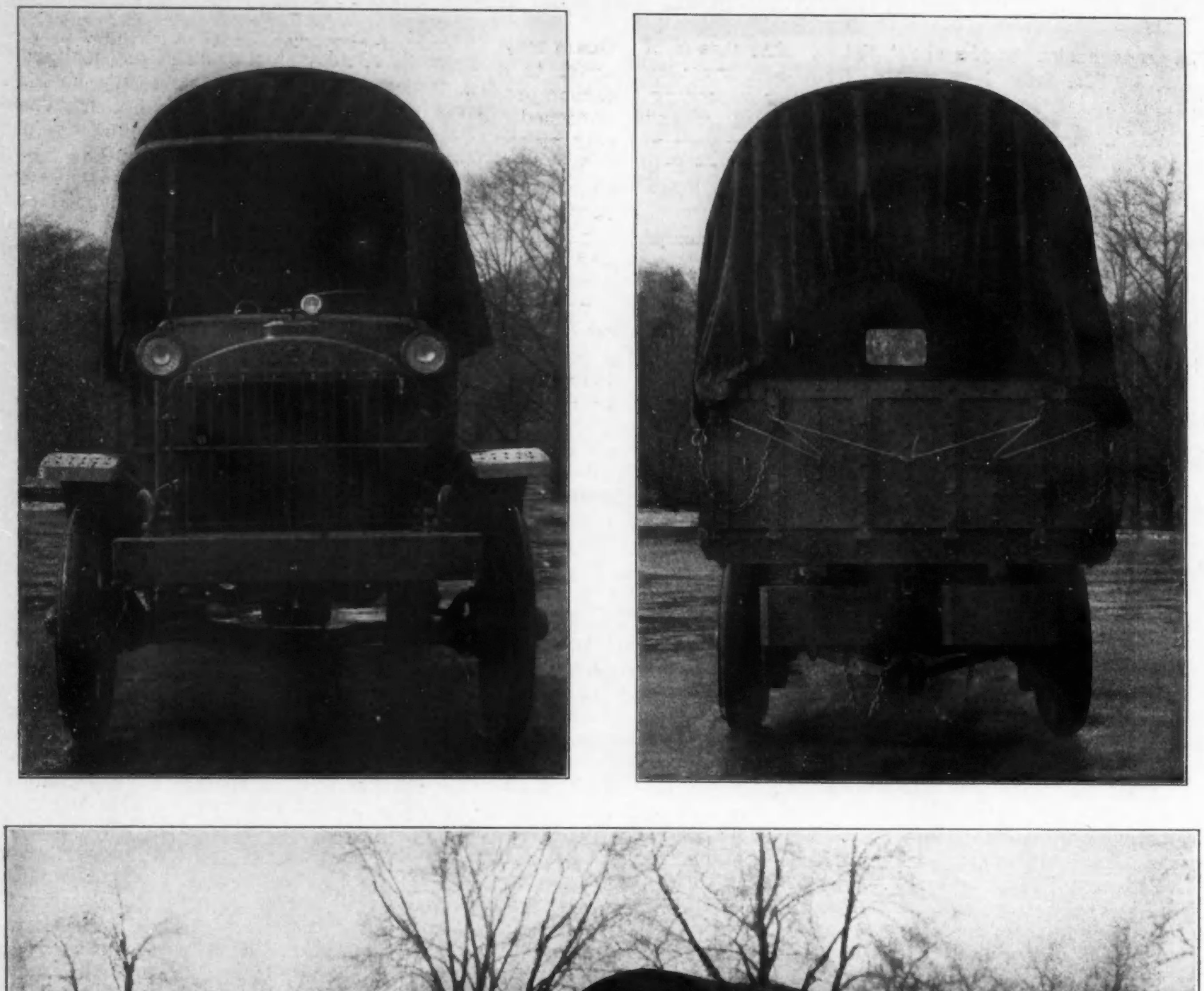
Annual Meeting Paper *Illustrated with* Charts

When the Government first summoned the engineers to Washington to design a U. S. army truck, the axle engineers were divided into three groups, representing worm, internal gear and double reduction types of final drive. The program was to design and build two or more of each type. These were then to be tested, and the type to be adopted was to be based upon the all-around performance as shown by the tests.

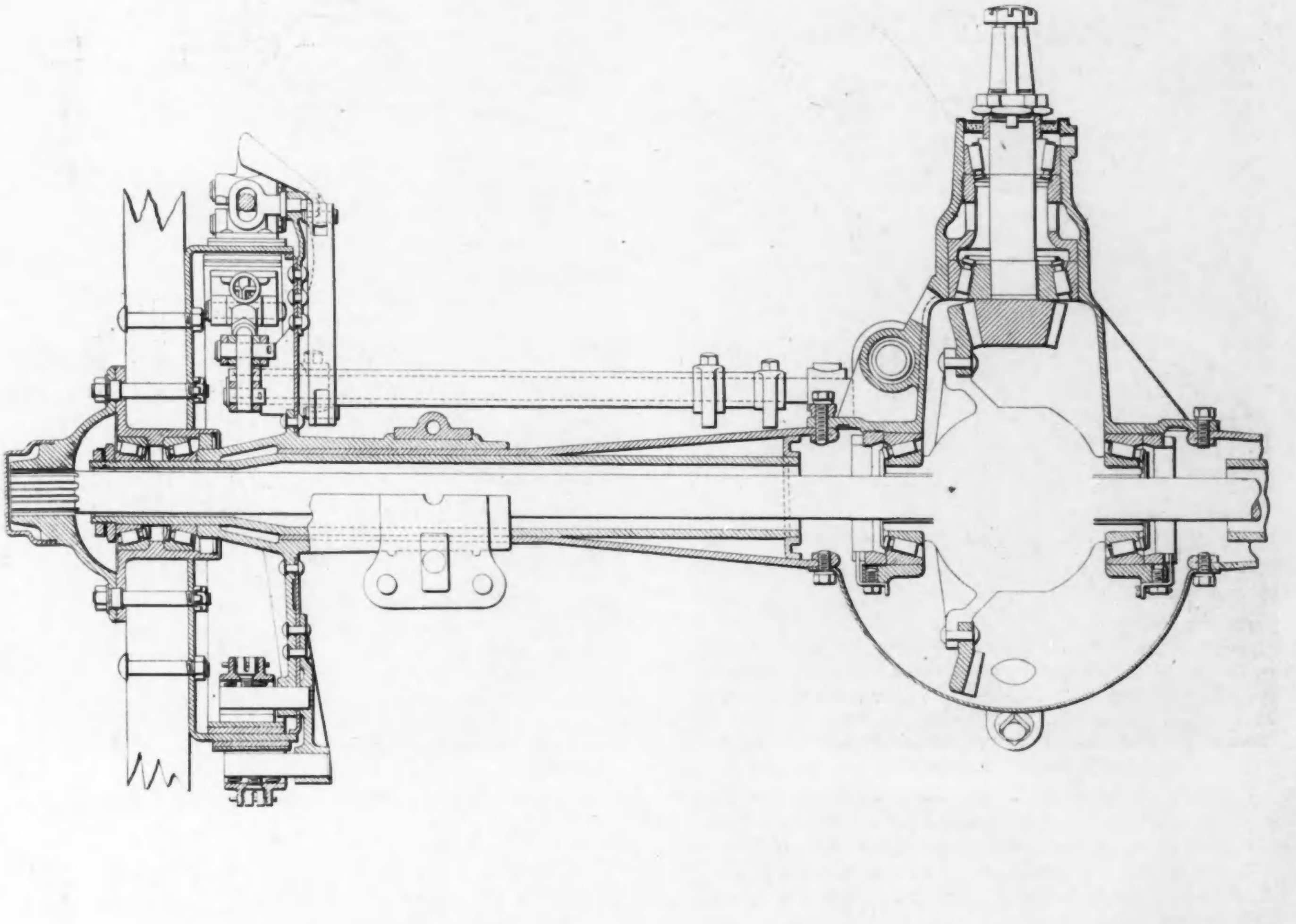
The limited time however upset this procedure, and it became necessary to make a quick decision, at least in the case of the Class B design. It is not necessary to here discuss the purpose the War Department had in view in its selection of worm type for the Class B axle. Suffice it to say that the wide use of this type as well as the production conditions were large factors. The question of performance and absolute reliability through critical periods eliminated all inclinations on the part of the engineers to introduce features of an experimental nature. The governing keynote is Sturdiness, Simplicity of Construction and Simplification of the Field Service Problem.

An instance of the latter is manifested in the Class B axles particularly, in which only three bearing sizes are used in the front and rear—the front inner bearing

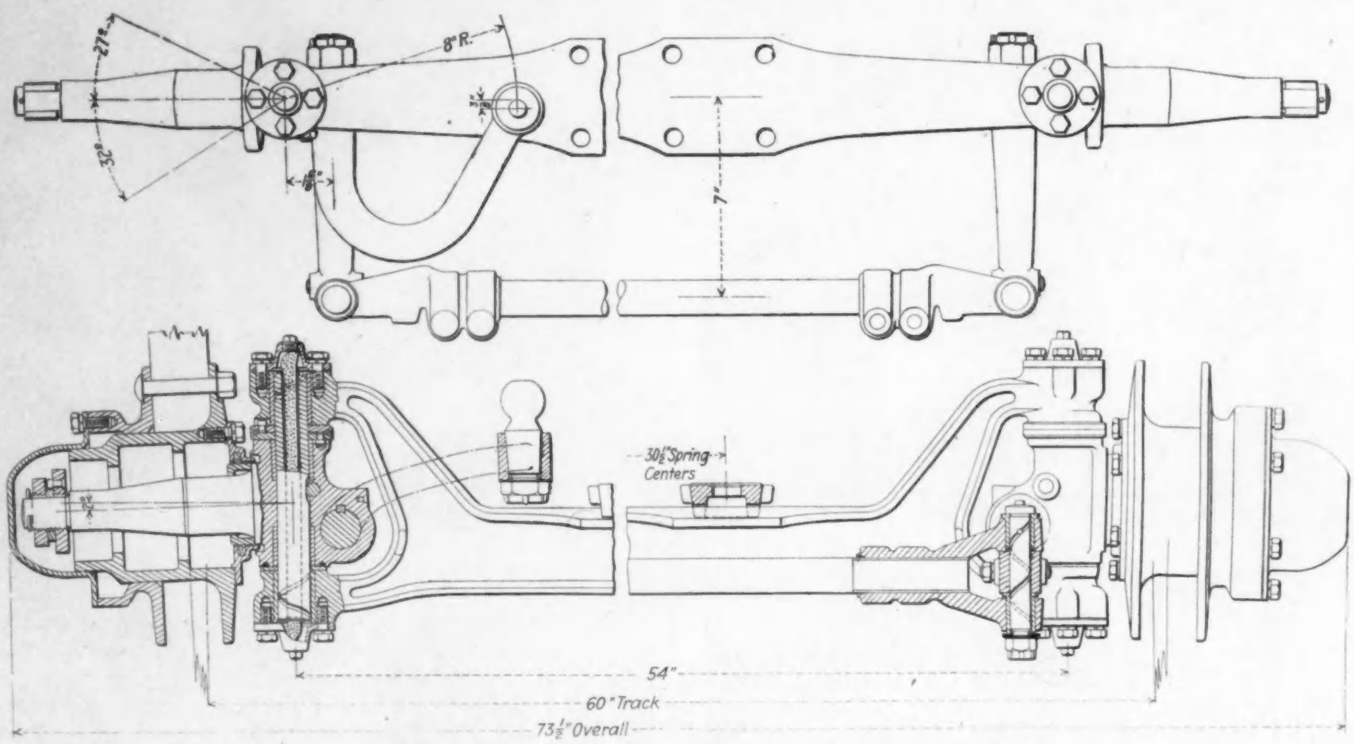
*Engineer, Timken-Detroit Axle Company.



Class A Sample Military Truck Recently Completed for Quartermaster Department



Cross-Sectional Views of Rear Axles for Class AA (Top) and Class A Military Motor Trucks



FRONT AXLE DESIGNED FOR CLASS A MILITARY MOTOR TRUCK

interchanging with the worm bearings—the rear wheel bearings being alike and interchanging with the differential bearings, and the front wheel outer the only odd size. The front carries only one size of screw, a total of forty-four being used. Such is also the case in the rear, where the only right and left-hand parts are the wheel-spindle nuts and the brake anchors. The brake levers, brake shafts, shaft brackets and toggles are all interchangeable.

CONSTRUCTION OF FRONT AXLES

The Class A and B front axles are, except for proportionate dimensions, the same. The hub closure is designed with the object of presenting the smallest diameter for the felt rubbing face. A flange on the felt retainer rotating within a groove in the knuckle prevents the dirt from reaching the felt, and an additional groove immediately outside the felt is intended to divert any water from reaching it, except possibly at the bottom.

Particular attention has been paid to the lubrication of the knuckle pin. This is made of carbon steel, hardened and ground; the bushings being of similar material and pressed into the ends of the center forging, this construction providing a wide bearing spread. The hollow pin contains an oil wick, the ample dimensions of which allow for a generous supply of oil.

Since the ordinary grease commonly used for lubricating this particular place leaves much to be desired, it was argued that even at the expense of considerable leakage oil would be preferable. The experience with the samples is ample testimony of the soundness of this reasoning.

The thrust washers are grooved, the oil entering through recesses next to the pin. The dust device consists of a brass ring floating in opposite circular grooves in the washers. The bottom of the knuckle is closed by means of a similar expanding ring. These rings are intended more to keep out the dirt than to keep in the oil.

The cross tube end-pins are fastened to the arms in order to allow for the maximum bearing surface with minimum weight. A draw key is used for this purpose. The bushings are pressed into the end forging. The lubrication is by oil. No attempt is made to hold the oil, a self-feeding oiler being used.

The regular Elliott type was chosen because of the opportunity it presented of bringing the pivot centers close to gage line, and because it was a simpler manufacturing proposition.

The center forging material is No. 1035 S. A. E. Steel, heat-treated; the knuckles and arms No. 3130 S. A. E. Steel, heat-treated; hubs and flanges, malleable iron. In short, the S. A. E. materials and heat-treatments are used wherever possible.

The steering-arms are forged to shape, except for a hand-bending operation on the ball arm. They are secured in the knuckles by taper fits of generous dimensions, and keyed.

The Class AA front axle is of similar type, without the refinements of detail used in the A and B designs. This was necessary because of the limited weight allowed for the lightest axle. The general construction is distinctly passenger type. The lubrication is all with grease, the limitations imposed, as before stated, not permitting a design suitable for oil without approaching features of an experimental nature.

The hubs, unlike those of the two heavier types, are of pressed steel, which embodies the necessary strength with additional lightness. The material is otherwise the same as for the A and B, part for part.

CLASS B REAR AXLE

During the early stage of development of the Class B truck, it became apparent that the weight would far exceed that of the commercial 3½-ton truck. This, coupled with the severity of service, brought about a design which, for strength, compares favorably with the average 5-ton commercial rear axle. The weight alone, however, was not the only determining factor. The War

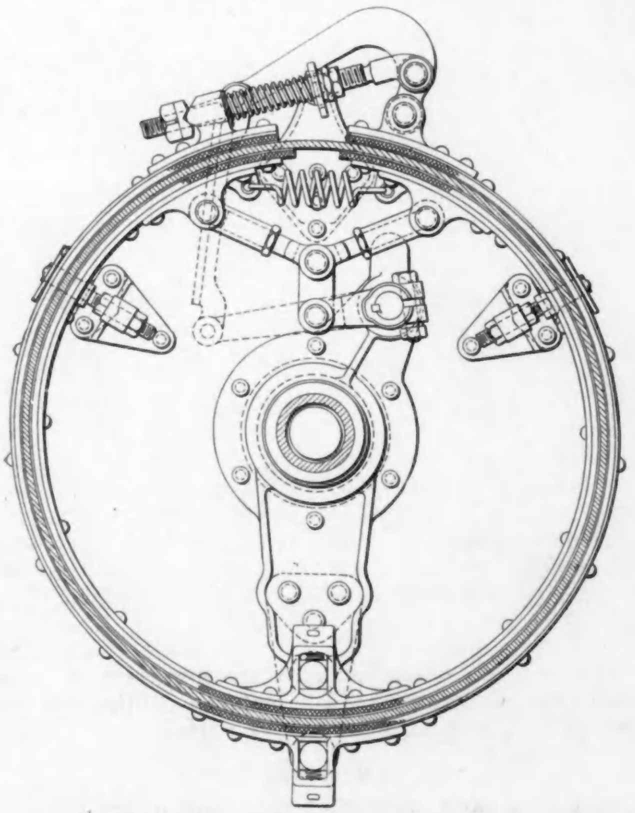
Department specification for the locking differential necessitated a shaft diameter of a size that put the bearings and tubes into the 5-ton class. It was not considered safe to calculate the shaft stresses except by the engine torque. The material in the shaft was chosen of a steel such as would present the least uncertainty in heat-treatment.

These conditions made it possible, without any sacrifice, to use one size of bearing for the wheels and differential. The drive-plates are shrunk onto the shafts (ten splines being used in each end) and piloted into the hub flange, to which it is secured by fourteen ½-in. bolts. Studs were considered, but through bolts were given preference.

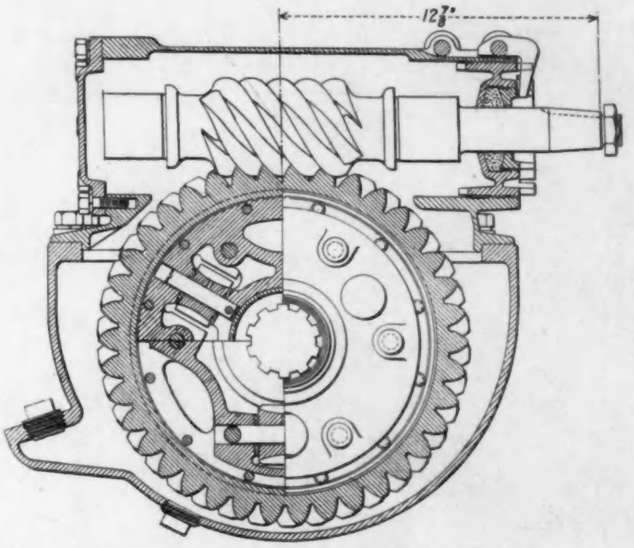
The housing construction is of a Timken type, either cast or pressed steel, with a square section from the center bowl out; the tubes are pressed into place, a retaining screw being provided for safety. The tube extends to the bowl of the housing, and a reinforcing plate is fitted over the inner end and riveted or welded to the top and bottom of the housing shell.

The forged steel spring-seats are in two parts—top and bottom—each fitted over the housing on machined surfaces and doweled for side position.

The worm and gear are of the David Brown type, with an 8⅝-in. center distance. The pressure angle is 30 deg., the linear pitch 1.1562 in., and the lead angle is 24 deg. 20 min. Compared with the sizes used in commercial trucks, this design appears somewhat inadequate. The limiting factor, however, is ground clearance, which the military authorities considered so necessary as to sacrifice possibly the maximum life of the worm gear. It might be mentioned that the samples, giving due consideration to the comparatively short mileage, do not indicate that such a sacrifice has been made.



Brake System Used on Class B Rear Axle



Cross-Section Showing Class B Worm Gear

The gear is mounted onto the differential by means of corrugations 3.16 by 1/16 in. on one side for one-half the width of the gear seat and piloted by the other side. It is secured against side thrust by a ring held by twelve rivets and against a shoulder on the opposite side. This mounting, although not new, gives large space for the differential as well as economy in bronze.

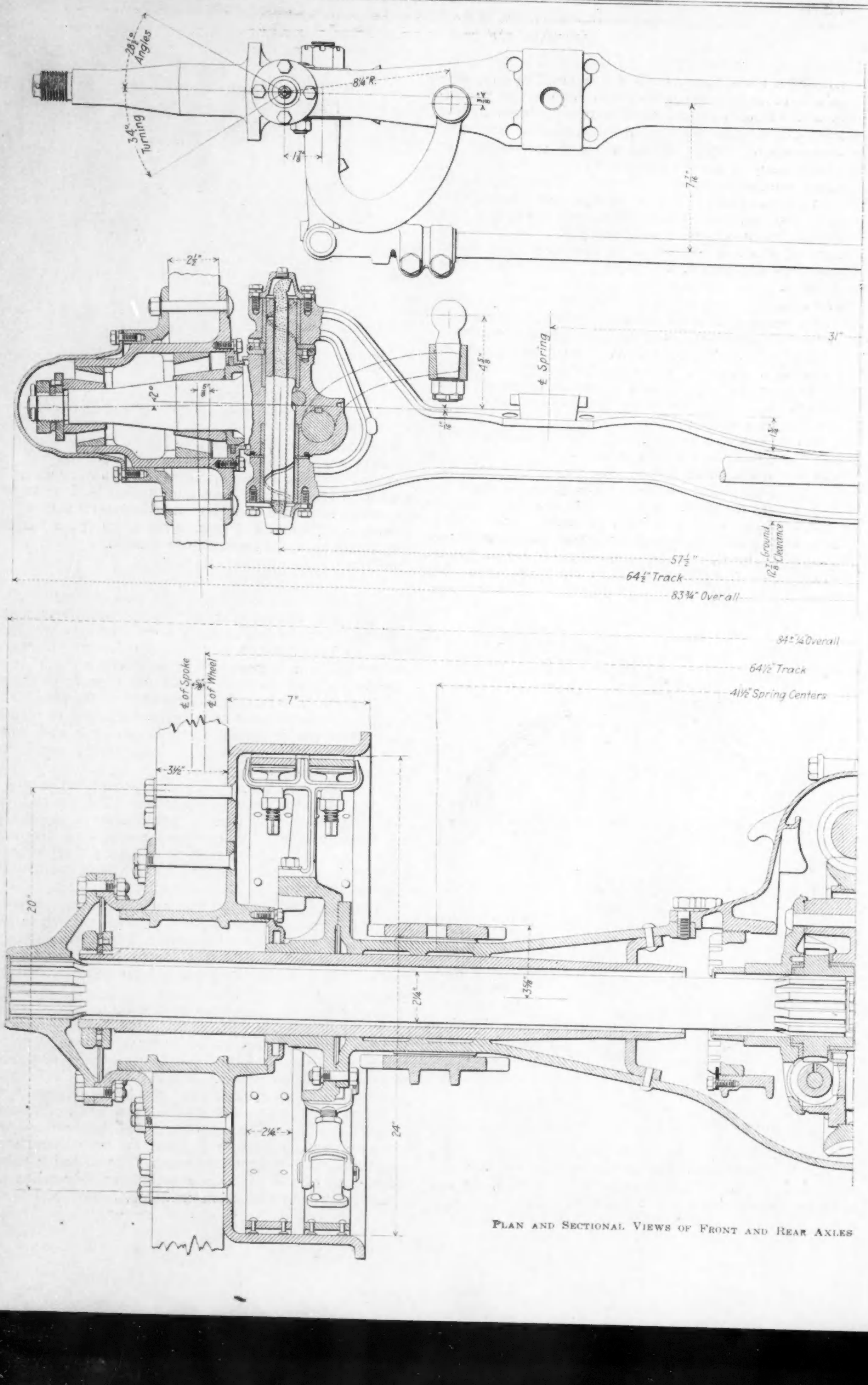
Differential Possibilities

The differential originally chosen was of a well-known locking type, but because of the comparatively small number in use for this capacity a common type was substituted. This question has since been reopened, and at present the War Department is considering three possibilities—the common type, the locking type, or no differential at all. The locking differentials on the samples so far have given complete satisfaction and seem to be adequate from the standpoint both of strength and wear. It is, however, a proprietary article, thereby conflicting with the Government's policy.

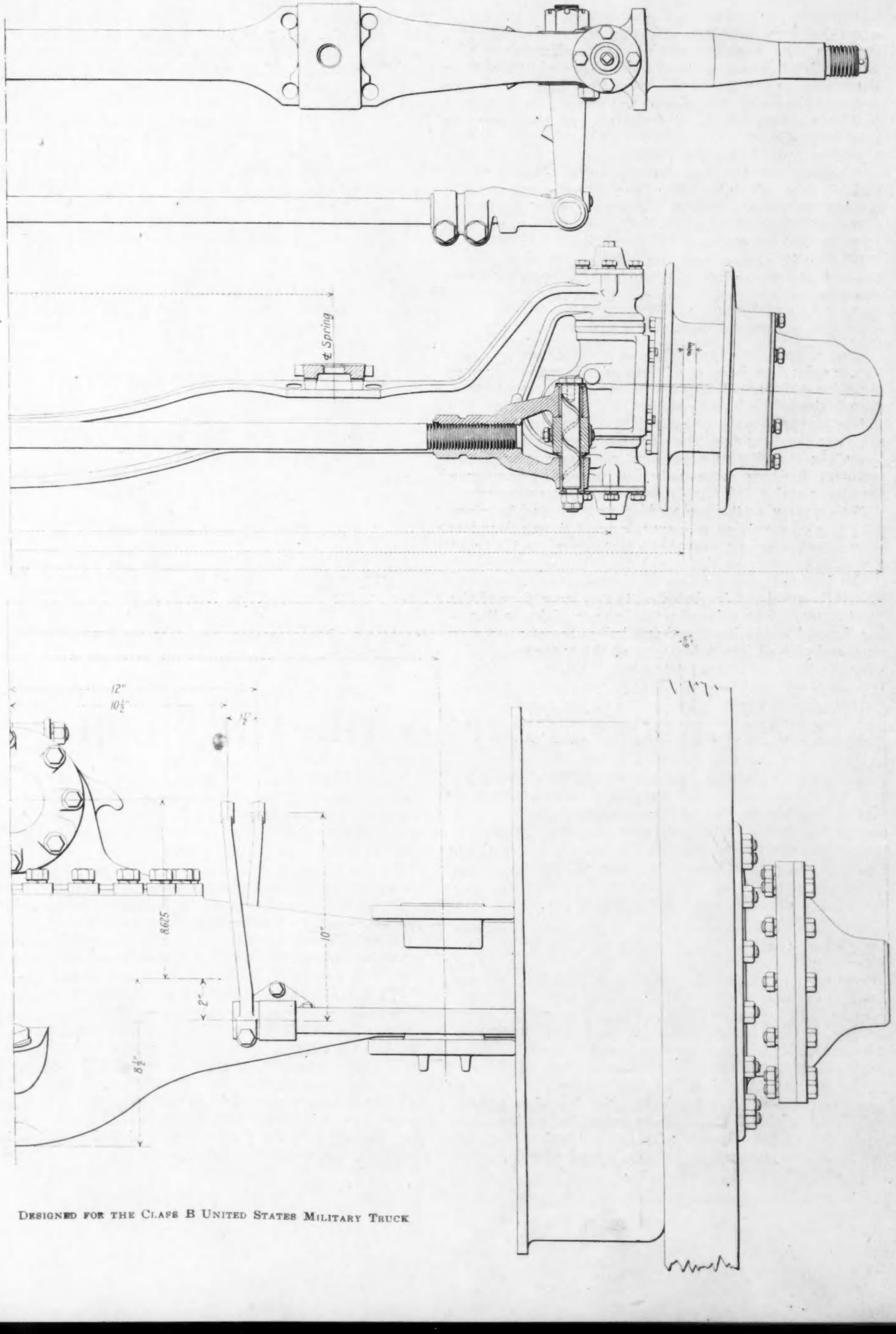
The differential worm and gear are mounted on a carrier piloted at the top of the housing. The gear adjustment is made by slotted and threaded rings in back of the bearing cups. The cups are clamped to the main pedestals by caps, nickel steel studs 1-in. diameter being used. The whole unit can be removed from the housing without disturbing any adjustments.

Throughout the axle the various parts have, wherever possible, been so designed as to permit assembling and dissembling as the following units: First, the shaft and drive-plates; second, the wheel, drum, bearings and dust washer; third, the brake anchor and bands, levers, shafts; and fourth, carrier and parts.

The brakes are side by side and are made of rolled stock, toggle operated, 24-in. diameter and 2½-in. wide. The proper place for brakes is unquestionably on the rear wheels, provided they can be made of a size large enough to be dependable. Since the War Department permitted a 24-in. diameter the problem was merely one of designing a brake easy of adjustment and of dissembling or relining. The toggle brake in this instance was given preference because it made accurate forming of bands and machining unnecessary. The objection raised on account of the rattle is a secondary item when the braking power available is considered.



Plan and Sectional Views of Front and Rear Axles



DESIGNED FOR THE CLASS B UNITED STATES MILITARY TRUCK

Besides the anchor and supporting pin (which is square) three additional adjusting screws are provided for each band, designed so as to make adjustments possible without removing the wheel and drum. These have mushroom heads to prevent pounding into the softer metal of the band. The drums are pressed steel, flanged to give rigidity. S. A. E. materials and standards are used throughout.

All bearings are tapered roller except the internal gear spur pinion and the wheel bearings on the Class A truck, which are of straight roller type. The manufacturers making the internal gear axles recommend this practice on the ground that failure to adjust would cause a misalignment of the gears.

Oilers and grease cups have been omitted wherever possible and pipe plugs substituted. All nuts of large diameter and fine threads are case-hardened.

Classes A and AA Rear Axles

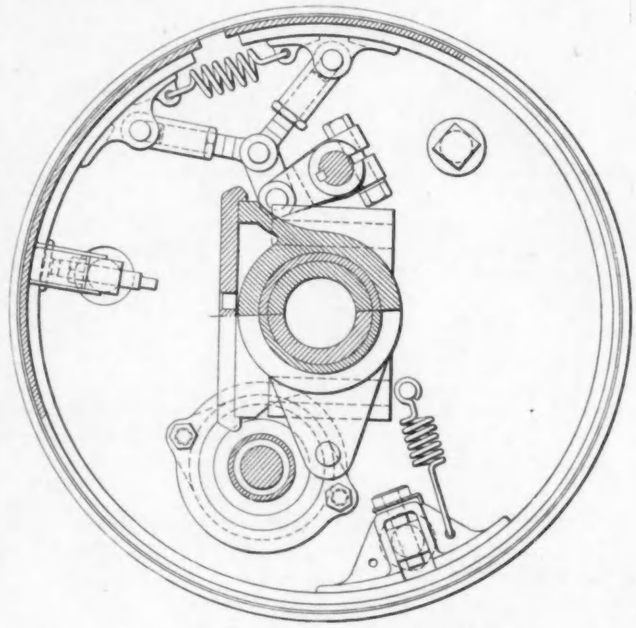
The internal-gear type axle was selected for the Class A rear axle; first, because of the available manufacturing facilities, and second, because of the high ground clearance desired.

The countershaft was located in the rear of the load carrying member; first, it made possible a simple assembling job; second, gear adjustment can be made by simply removing the rear cover plate (as in current passenger practice); and, third, the lighter weight thus secured.

The question of the loads added to the wheel bearings with this construction was considered, but was found to be negligible as contrasted to those due to the road shocks.

The load-carrying member is a pressed-steel housing. The differential carrier is bolted to the inner face of the front flange. The drive-shaft tubes are 1/8-in. wall tubing, flanged at the inner end and bolted to the aluminum case, and piloted into a felt ring at the outer end.

The bevel gears are somewhat larger than necessary owing to the fact that provision had to be made for a locking differential. The wheel brake (emergency) is of the toggle type, the service brake being attached to the transmission.



View of Class A Rear Brakes

The Class AA rear axle is of the generally accepted full-floating passenger-car type, selected because of the large production possible. The ring gear is 12 7/8-in. diameter, 61-tooth pinion and 11-tooth, 4 3/4-in. pitch spiral-bevel gear. Current practice has been followed in each feature.

THE WAR'S EFFECT ON THE AUTOMOBILE

On Dec. 27 the Metropolitan Section held a meeting for which A. Ludlow Clayden submitted a paper on The War's Effect on the Automobile Industry. Ray Sherman of *Motor World* presented the paper, as governmental activities prevented Mr. Clayden from attending.

In analyzing the effect of the war on the American automobile industry Mr. Clayden assumed that the war would last a year or more. He said in part:

"The American passenger car of the near future is going to be one in which economy is a strong feature. A car of which the first cost, plus the maintenance cost over a period of years, will make a good showing. We are about to exchange 'what will she do on high' for 'what will she do to the gallon?' It is a fact that already those cars which have a reputation for economical operation have suffered far less than those which are known as wonderful performers.

"The average American car has exacted too high a price for the service it rendered. Not too high a first price, but too high a maintenance price. It has been too big, too heavy, too powerful; too extravagant of fuel, of oil, and of tires, and too frequently in need of repair.

"This is the reason why motorcycles have had such an immense vogue on the other side of the Atlantic. The average American says 'I can't ride a motorcycle. It isn't in keeping with my position.' True enough—last year—but will it be true this year?

"We are nearly at the end of gasoline as we know it. We doubt the fuel ten years hence will still be called gasoline but it will not operate a 1918 gasoline car. We have got to learn to sacrifice the absurdities of 'flexibility' existing in the modern engine in order to use a fuel which we will be able to buy for a third the present price.

"The automobile has been one of the great inventions of civilization. It has altered for the better conditions of life in almost every country on earth. Yet all the time it was doing this it was being designed for pleasurable performance rather than for the useful work which formed the major reason for its existence. The world has taken a luxury offered to it, and used that luxury as a necessity. It is time that the true reason for the enormous demand for cars was appreciated and reflected in automobile engineering and design."

Vol. II January, 1918 No. 1

Fuel for Automotive Apparatus

By Dr. E. W. Dean* (*Non-Member*)

Annual Meeting Paper *Illustrated with* Charts

THE present paper deals with certain mutual problems of the two industries of automotive engineering and petroleum refining. A brief preliminary discussion seems to be in order to explain why a chemist is elected to present information apparently not related to his normal field of work.

The Bureau of Mines has for several years been conducting scientific investigations in the field of petroleum technology. This work was begun through the establishment of a chemical laboratory for the testing of oils. It was, however, recognized at an early date that little of practical importance could be accomplished if activities were limited to such a narrow scope. When the present petroleum division of the Bureau was organized the chemical section of this division was made to include with its laboratory investigations studies in the fields of petroleum refining and utilization.

The Bureau was early impressed with the general failure of producers and users of petroleum products to work together in dealing with the many problems that are of mutual interest. It is now thought that no more important end can be accomplished than to interest refiners and automotive engineers in the advantages of cooperation.

The principal petroleum products in which automotive engineers are interested are gasoline and lubricating oil. At present the latter does not seem to demand as much attention as the former and although there is little doubt as to the advantages to automotive engineers of a knowledge of the manufacture and properties of lubricants, it seems most desirable at present to concentrate efforts on the obtaining of a solution of the fuel problem. Fuels, as referred to in this paper, will be understood to mean the liquid fuels employed for operating internal combustion engines.

Gasoline Problem of Chief Interest

During the past few years the demand for gasoline has increased far more rapidly than the supply of raw material from which it is produced. Consequently there has been a general change in refinery practice with the production of so-called heavy gasolines, which are actually of relatively low average volatility. Although this change in quality is not necessarily deterioration it has brought to the attention of designers and users of internal combustion engines problems that did not exist in the past. Coincident with the change in quality there has been an increase in market price and a threatened condition of shortage in supply, so that the automotive engineering industry now has for solution the complex problem of devising equipment for the utilization of fuel of low volatility and at the same time getting a greater production of effective power from the quantity of gasoline used.

Properties and Production of Gasoline

Before beginning the most important part of this paper—that which discusses the possibilities of increasing the supply of fuel and the efficiency of its utilization—it is desirable to consider briefly the characteristic qualities of gasoline and the possibility of variation among these as influenced by refining methods. It is already understood by automotive engineers that the name gasoline is decidedly indefinite in its meaning and that it includes a heterogeneous class of petroleum products that have in common only the power of enabling automobilists to start and operate their engines. The following discussion is intended to show some of the characteristic differences among types and grades of gasoline and to explain and perhaps justify the changes in quality that have occurred recently.

Review of Refinery Methods

There are now three general methods by which gasoline is obtained from raw material. The oldest and still the most important is the ordinary refinery process of distillation from crude petroleum. A second method, also used in refineries, is the pressure-cracking process, in which, instead of crude petroleum, heavy distillates, such as gas oil or fuel oil, are used as raw material. The third method involves the extraction of gasoline from natural gas, either by the absorption or the compression process. The product thus obtained is commonly called casinghead gasoline.

An adequate discussion of the details of any one of these processes is beyond the scope of the present paper and it is therefore necessary to pass this interesting field with a brief word of mention. It may be stated, however, that the straight distillation method is highly developed and that improvements in it offer only moderate possibility of increasing the supply of fuel. Some gasoline and naphtha still goes into the kerosene fractions, but wastes of this sort are not important in the present situation. The cracking process is as yet only partly developed, and in the future its use will undoubtedly be considerably increased. It is not to be expected, however, that there will be more than gradual development in this field even if the Standard Oil Company should decide to license the Burton process for general use at an early date.

Other cracking processes are being installed on a commercial scale but as yet seem to be limited to the small unit stage. The extraction of gasoline from natural gas is likewise a method that is growing in use and it is difficult to predict just what can be expected from it on the basis of data now at hand. The recently developed absorption process makes it profitable to extract gasoline from gas not sufficiently rich to be treated by the compression process but resources in this direction probably cannot be expected to develop in more than gradual fashion.

Properties of Straight Refinery Gasoline

The most familiar type of fuel, that produced from crude oil by the distillation method, is commonly described as "straight refinery" gasoline. This type of gasoline, as ordinarily refined, is colorless and possesses an odor varying from actual sweetness to the slightly disagreeable quality characteristic of kerosene. The hydrocarbons of straight refinery gasoline are of the so-called

*Chemist, Petroleum Division, U. S. Bureau of Mines.

saturated class and are inactive when treated with such reagents as bromine, iodine and cold concentrated sulphuric acid. They are, however, slightly attacked by fuming sulphuric acid of moderate strength and by nitro-sulphuric acid mixture.

Straight refinery gasoline may vary within wide limits in the property of volatility but the distillation curves obtained by plotting the results by the Engler test have a more or less characteristic form. Fig. 1 shows the distillation curves of three gasolines of various degrees of volatility obtained from different types of crude petroleum. The percentage marks are plotted as ordinates and temperatures as abscissas. The curves slope upward rather sharply from the initial boiling point to approximately the 20 per cent mark. From this point the graph proceeds as practically a straight line sloping gradually upward to about the 90 per cent mark. Here another steeper slope commences, which generally proceeds to

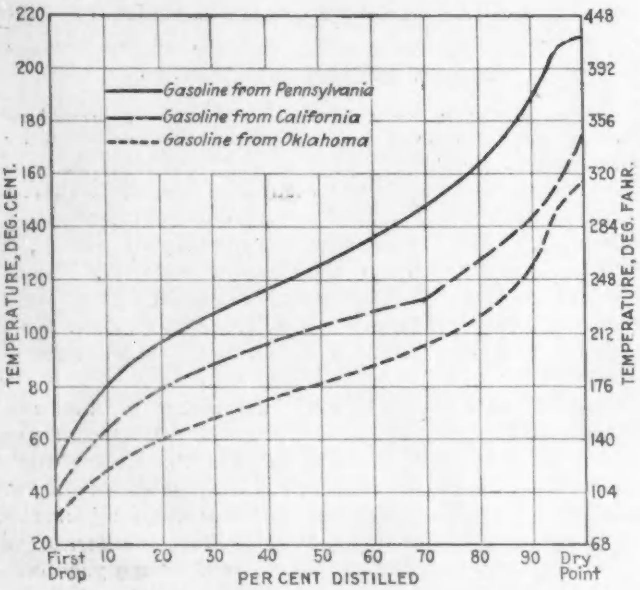


FIG. 1—DISTILLATION CURVES OF DIFFERENT GASOLINES

about the 95 per cent mark, and then breaks sharply. This break is due to the fact that the dry point is not actually the 100 per cent mark.

GASOLINE FROM CRACKING PROCESSES

The characteristic properties of cracked gasoline are odor and content of unsaturated or olefin hydrocarbons. Untreated cracked distillates have a particularly rank and unpleasant odor, which can however be practically eliminated by treatment with a small percentage of sulphuric acid. The odor of a well-refined cracked gasoline is not noticeably disagreeable but has a definite quality and pungency that distinguishes it from gasoline of the straight refinery type. This odor is admitted to be somewhat undesirable but is not a serious objection. The other characteristic property of cracked gasoline is a considerable content of unsaturated hydrocarbons, compounds that react with such chemicals as bromine, iodine or concentrated sulphuric acid.

The amount of material removable from the gasoline by treatment with an excess of cold concentrated sulphuric acid is generally called the percentage of unsaturation. The cracked gasolines usually marketed are acid refined and blended with straight run and casinghead products and generally do not contain over six per cent of hydrocarbons removable by sulphuric acid. The volatility curves of cracked gasolines are, like those of straight-run products, controlled by the method of refining but the characteristic general form is the same as for the refinery distillates. Fig. 2 shows the distillation curve of an unblended cracked gasoline compared with that of a straight refinery product that happens to be of the same average volatility. The form of the two curves is almost identical.

CASINGHEAD OR NATURAL GAS GASOLINE

Natural gas gasoline is of such a volatile nature that it is usually blended with a considerable proportion of heavier gasoline to reduce its vapor pressure so that it can be shipped and used safely. Its chemical and some of its physical properties are identical with those of the straight refinery type of product. It is colorless, of sweet odor, and inactive with sulphuric acid, bromine and iodine. The volatility of unblended casinghead gasoline is a property concerning which the Bureau has few data. This product is rarely used as such except perhaps in gasoline gas machines. It is usually marketed as a blend, either with a heavy naphtha produced by the ordinary refinery process or with straight refinery gasoline of high endpoint.

The term naphtha is used to designate a distillate which does not contain the low boiling fractions included with ordinary gasoline. The blending of casinghead gasoline with the straight run product is generally done in refineries, many of which make a practice of buying all of the former they can obtain and adding it to the distillates produced from crude petroleum. The blending of casinghead gasoline with naphtha is generally done either by the companies that produce the former from natural gas or else by blending companies.

Fig. 3 shows the characteristic distillation curves of blended casinghead gasoline as compared with the typical curve of a straight run product. One of the curves represents a sample of fuel that was obviously prepared by blending approximately equal quantities of casinghead and kerosene. This is a "shocking example" of what a blended gasoline ought not to be and is the only sample of this type of fuel that the Bureau of Mines has ever discovered for sale in the market.

Two of the other curves represent blends, one with heavy refinery gasoline, the other with naphtha. The naphtha blend has a lower initial boiling point and a higher content of volatile constituents than the gasoline blend. Both are fuels of good quality and are probably superior in starting properties to the straight run gasoline represented by the distillation curves shown for comparison.

DESIRABLE PROPERTIES OF GASOLINE

The desirable properties of gasoline and some laboratory tests and specifications for determining them have been discussed in a recent technical paper* published by the Bureau of Mines. This paper was intended chiefly for the information of refineries and chemists but a brief review of some of the considerations mentioned may not be out of place here.

The requirements for a satisfactory fuel are as follows:

(1) That it shall permit ready starting of a cold engine;

*Dean, E. W., Motor Gasoline, Properties, Laboratory Methods of Testing, and Practical Specifications. Bureau of Mines technical paper 166 (1917), 27 pages.

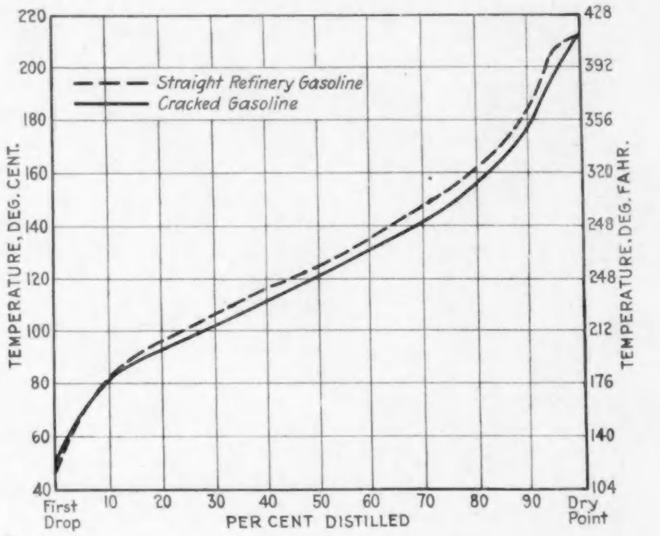


FIG. 2—DISTILLATION CURVES FOR CRACKED AND REFINED GASOLINES

(2) That it shall permit smooth and reliable operation of an engine at varied and rapidly changing loads and speeds;

(3) That it shall not contain substances such as free acid which by corrosion or otherwise injure an engine;

(4) That there shall be a minimum tendency for either solid or liquid residues to accumulate in the engine.

It is also desirable that gasoline shall not be of such nature as to be subject to excessive evaporation losses in storage or handling and that it shall not be too dangerous. These latter requirements are indefinite, however, and vary with climatic conditions. In addition they are likely to interfere with the starting qualities of gasoline if satisfied too thoroughly.

The second and third requirements are generally satisfied by present refinery practice. The Bureau has heard no complaints either of corrosive action due to free acid in gasoline or of lack of flexibility in engine operation. The first requirement, easy starting of cold engines, seems to be least generally met, as the present tendency is to market gasoline of relatively low average volatility. There seems to be little possibility of improvement in this quality and the problem of easy starting will undoubtedly have to be solved by engine designers.

The requirement that gasoline shall not leave a solid or liquid residue in the engine is one that frequently is not satisfied, according to reports from many makers and users of engines. Complaints are heard to the effect that there are sometimes gummy deposits in carbureters and manifolds, that excessive carbon deposits collect in cylinders, and that heavy fractions of gasoline are unburned and forced past cylinder rings into the crankcase oil. Difficulties are without question frequently due to improper engine adjustment and operation but the gasoline is undoubtedly to blame in some cases. The accumulation of gummy deposits in carbureters and manifolds is a type of trouble for which there does not at present seem to be any definitely established explanation. The Bureau is at present studying this problem but has not yet enough information at hand to make it desirable to attempt an adequate discussion. Fortunately this type of engine trouble does not seem to be of frequent occurrence.

Types of Cylinder Residue

The two most important types of residue are carbon, which collects in the explosion chamber, and heavy fractions of the gasoline that condense and escape past the piston rings into the crankcase. Carbon deposition is frequently due to improper carbureter adjustment and can generally be minimized if a sufficiently lean mixture is used. Such deposition is, however, in common with crankcase oil pollution, often due to the use of gasoline containing too great a proportion of heavy ends, which in everyday language means kerosene. The term used by the refiner and oil chemist is "high endpoint" and means that when the gasoline is subjected to a distillation test the presence of high-boiling fractions is indicated. These fractions undoubtedly are not vaporized even in cases when no fuel troubles are experienced but are burned while in the form of a fine spray, in the same way that coal dust or grain dust burns explosively.

Fuel trouble due to high endpoint occurs when heavy constituents are present in excessive proportion; so that instead of holding up in spray form drops of considerable size precipitate. These settle on cylinder walls and piston heads and cause trouble in a variety of ways. Lubrication is interfered with, there is deposition of carbon through cracking and liquid residues may be forced past the piston rings and mixed with the lubricating oil. There may be other ways in which trouble is caused but those already mentioned are sufficient to indicate the disadvantage attendant upon the use of gasoline of too high endpoint in the average engine.

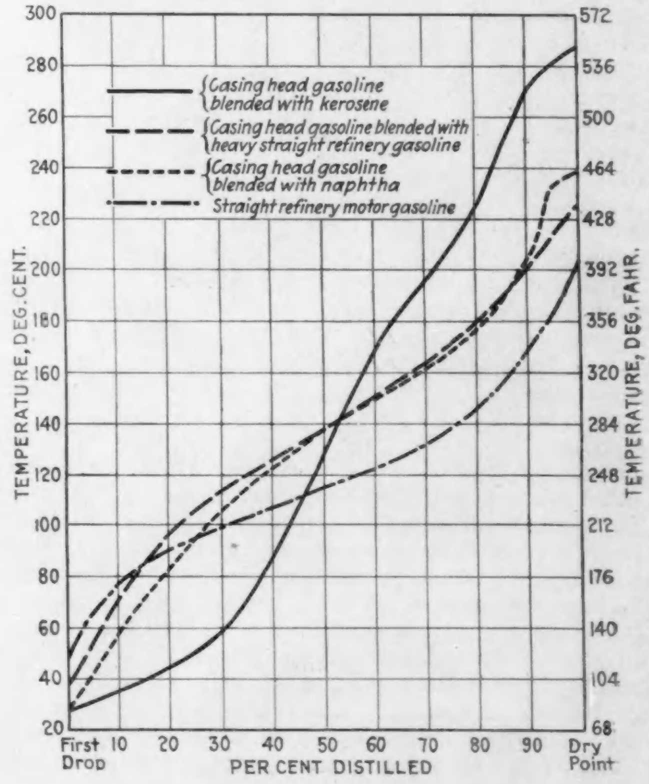


FIG. 3—BLENDED CASINGHEAD GASOLINE COMPARED WITH STRAIGHT RUN PRODUCT

Unfortunately it is a difficult matter to set any kind of a definite limit that serves to indicate when the danger line in endpoint is passed. There are on record cases that seem to indicate that trouble has been caused by the use of gasoline of endpoint lower than 400 deg. fahr. On the other hand a tremendous quantity of gasoline is being used, generally without more than imaginary fuel trouble, which has an endpoint as high as 450 deg. In some cases 500 deg. endpoint gasolines are satisfactorily employed and the author is acquainted with one man who during the summer months regularly mixed with his gasoline a fourth of its volume of kerosene and obtains satisfactory results.

There is no question upon which it is easier to start an argument than on the proper endpoint of gasoline. The Bureau of Mines has up to date taken the stand that the only evidence it could depend on is the general marketing practice of refiners and on this basis it appears that the maximum satisfactory endpoint for a properly balanced gasoline is between the limits of 400 deg. and 450 deg. fahr.

Objections to Blended and Cracked Products

There is still a tendency on the part of some users to consider that the only desirable variety of gasoline is a highly volatile product obtained by the straight refinery method. Blended casinghead gasolines are claimed to be dangerous, to deposit carbon and to stratify or change their composition in different parts of a storage system. Cracked gasolines are believed to be of vile odor and to polymerize in carbureters and manifolds and to leave excessive carbon deposits in cylinders. Straight refinery gasolines of high endpoint are likewise condemned on the ground that they are bad in starting an engine and that they deposit carbon and pollute the crankcase oil.

These beliefs are not without some foundation of fact. There is little doubt that from the point of view of the average user the most satisfactory fuel ever produced was a straight refinery gasoline testing 70-deg. Baumé or higher. This type of product was relatively dangerous in handling and was subject to high evaporation losses but these disadvantages were ones to which users of the past were educated and which were considered characteristic of gasoline. The fact that gasoline was treated with proper respect minimized in a large degree the first disadvantage and its relatively low cost minimized the second. Gasoline of this type worked satisfactorily under almost any sort of engine conditions and in any event was rarely blamed for trouble. In earlier days the custom when anything went wrong was to swear at the engine rather than at the fuel.

When the newer types of gasoline were first introduced the trouble and dissatisfaction that immediately arose was not without some just cause. In many cases the process of blending casinghead gasoline was not properly conducted and in any event 70-deg. Baumé gasolines of this type could not help being dangerously volatile. Methods of refining cracked gasoline were not perfected when these distillates were first marketed and they certainly did not compare favorably with straight run products in the matter of odor. It is likewise possible that there may actually have been cases of polymerization with troublesome deposition of gummy resinous material. When heavy straight refinery gasolines were first used engines were not designed or adjusted for their consumption and difficulties naturally arose. At present the methods employed in production and refining have been so improved that the bulk of the gasoline now on the market is really of excellent quality.

Both cracked and natural gas gasolines are put out in the form of blends that the average user cannot distinguish from straight refinery products and which have actual elements of superiority over the latter as now marketed. Heavy gasoline is, of course, deficient in the property of easy starting, but this objection is balanced by the fact that it actually contains more heat units per gallon and permits the development of more power. There are certain other admitted objections to relatively nonvolatile gasolines, but these are chiefly of the sort that can be obviated by proper engine design and adjustment. The Bureau has yet to receive proof that a gasoline of 400-deg. fahr. endpoint and a properly balanced range of volatility (which means that from 15 to 20 per cent of constituents distill below the boiling point of water and that the other fractions are reasonably evenly distributed) has failed to yield satisfactory results in a well-adjusted automobile engine of up-to-date design. In many cases gasolines of as high endpoint as 450 deg. fahr. are being used with satisfaction.

The main advantage of the present type of fuel is that its introduction has permitted the producers to keep pace with the demands made upon them. If the older standards of quality had been maintained prices would have soared far above their present high level and in addition there would have been today an actual shortage. Few users of automobiles would prefer limitation in their supply of fuel to the slight inconvenience of having to treat their engines with the care and respect these complicated mechanisms actually deserve.

Future Developments of Fuel Situation

It is a difficult matter to make accurate predictions for the future of a situation involving as many variables as does the fuel market. The Bureau of Mines is able to obtain reliable information concerning gasoline production and quality but realizes its inability to foresee all factors governing market conditions. It is therefore necessary to be conservative in attempting to tell what is likely to happen in any limited region or at any given time.

The one definite prospect for the immediate future is that there will be a considerable withdrawal of fuel from the home market for use in military operations. The quantity needed can be conservatively estimated for the present calendar year at about a fifth of the total production of the country. There is a likelihood that the quality will also be changed in the direction of further decrease in volatility because gasoline for military purposes will necessarily be of higher test than the present average commercial grade. If the total production is to be kept up to the present mark this will mean that domestic gasoline will be of lower volatility than now. In addition, refiners may be obliged to curtail their use of sulphuric acid, which will result in the marketing of gasoline of inferior color and odor.

The fuel situation is unfortunately one for which the ultimate successful termination of the war does not promise permanent relief. Estimates as to the number of years our resources of crude oil will last have been variously made and it is agreed that unless unexpected resources exist another generation will witness an actual shortage in the raw material from which gasoline is now produced. It is certain that the world cannot go on forever using up crude petroleum at the present rate of consumption and it is even now desirable to face this prospect squarely and make allowances for what the future is likely to bring. The possibilities of new supplies of fuel will therefore be discussed briefly, with the

idea of showing the relative importance of the sources of relief mentioned.

Use of Alcohol

When looking for a future supply of any product it is natural to consider raw material that can be continuously produced instead of taken from a stored up-deposit. Alcohol is a volatile liquid fuel that is known to be satisfactory for use in internal combustion engines and which can be produced by the simple process of fermentation from any source of sugar. Unfortunately, however, evidence is still lacking that alcohol can be produced sufficiently cheaply enough to compete with various other forms of fuel that come to us as it were ready made. Just at present alcohol sells at a price that almost prohibits its use even as an anti-freeze compound. This

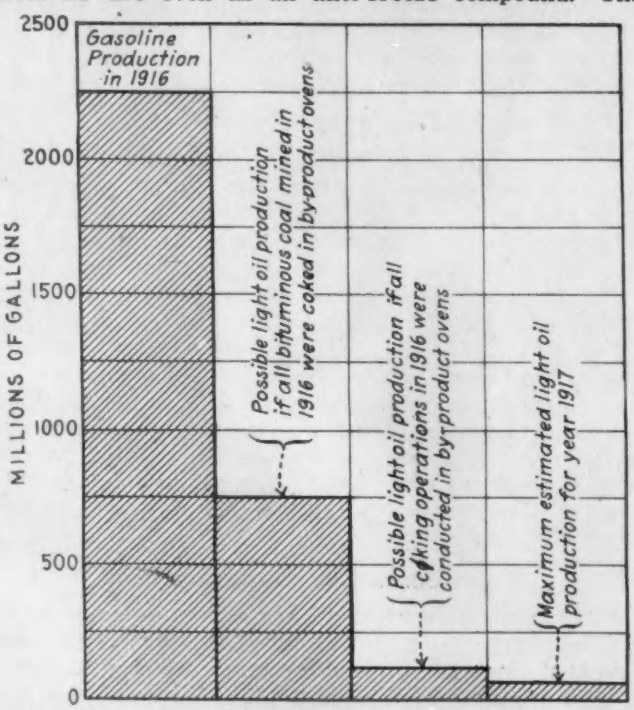


FIG. 4—FUEL FROM COAL COMPARED WITH ACTUAL GASOLINE PRODUCED

situation is of course abnormal and there is every prospect that in the future alcohol may be on the market at a lower price than ever in the past.

The economical utilization of alcohol requires, however, engines that operate at compression pressures far greater than now employed for gasoline, which fact introduces complications that relegate alcohol to the far distant future as a potential substitute for gasoline. For the present it seems that alcohol is only of academic interest as fuel except perhaps in localities where gasoline is expensive and scarce and the most promising raw material for alcohol manufacture is cheap. Such a situation already promises to develop in the Hawaiian Islands; gasoline is obtained there only after shipment over sea, but low grade unrefinable molasses is produced in large quantities.

Use of Coal-Tar Distillates

Another source of fuel that has received much attention is the by-product coking industry. The light oil constituents obtained by this process, such as benzol, toluol and xylol, are known to be satisfactory fuel, and although during the war the demand for them will continue to be greater than the supply, they will undoubtedly be marketed as fuel after the present abnormal production of explosives decreases. The use of these hydrocarbons either as such or blended with petroleum gasoline may increase the supply of fuel to a certain degree, but unfortunately the total available supply is relatively small. The following statistical information is interesting: The gasoline production of the United States for the calendar year 1916 has been variously given at from 2 to 2¼ billion gallons. The U. S. Bureau of Mines report on refinery operations for the year 1916 gives 2,058,880,596 gal. This includes a portion of the production of casinghead gasoline, which has been given as 104,212,809 gal. by J. D. Northrup, U. S. Geological Survey press bulletin No. 332 (August, 1917).

The production of coal-tar light oils for the same year was 36,600,000 gal. (C. E. Lesher, *Iron Age*, vol. 99, Feb. 22, 1917), and it has been estimated that during the year 1917 this production will have been increased to from 40 to 60 million gallons. These figures indicate that if the total production of coal-tar light oils of the country were added to the engine fuel supply the increase would be about 2 per cent. These figures represent coking operations already conducted by the by-product method. Figures based upon the total coke production of the country and even the total coal production of the country are not much more promising. The total coke produced in 1916 by both beehive and by-product ovens is given as 54,533,585 short tons and the total bituminous coal as 502,519,682 tons. (United States Geological Survey press bulletin No. 343, November 1917.) It is likewise recorded that the average yield of coke from a ton of coal is 1440 lb. and the average yield of light oil is 1.54 gal. (C. E. Lesher, Mineral Resources of the United States, 1916, part 2, pp 515-558.)

Calculations from these figures indicate that if all the coke produced in the country in 1916 had been made by the by-product process the 75,741,053 tons of coal used would have yielded 117,641,232 gal. of light oil, which if entirely devoted to use in internal combustion engines would have increased the available supply of fuel by a little more than 5 per cent. If all the bituminous coal produced had been coked and had yielded the same average quantity of light oil as the grade of coal now used for coking the light oil produced would have amounted to 753,779,523 gal., which proves to be less than 34 per cent of the gasoline production. These statistics show the limitations of the coking industry as a source of engine fuel. Fig. 4 represents graphically the theoretical quantities of fuels produceable from coal as compared with the gasoline actually produced. The use of coal-tar light oils as fuel will undoubtedly aid to increase the supply at some time in the future but they by no means promise to meet the total need for more gasoline.

New Resources of Crude Petroleum

It is by no means certain that tremendous quantities of crude petroleum exist that are not at present counted on, and producers are hopeful that such fields as the Mexican and even the Central American and South American fields may ultimately develop to a considerable degree of importance. The discovery of more crude would seem to be the easiest and most pleasant way of meeting the threatening fuel shortage, but this is a possibility that is so uncertain that it is hardly wise to place dependence on it.

Gasoline from Oil Shale

Vast deposits of oil bearing shale are known to exist in certain parts of this country and engine fuel can undoubtedly be obtained from this source. Here, however, as in the case of alcohol, the factor of expense in producing puts these products in the class of a resource that

may be utilized in the future. Scientists are already giving attention to the problem of working up these shales and it is hoped that satisfactory methods for obtaining fuel in maximum quantity and of the best possible quality will be developed by the time it becomes commercially practicable to use the shales. Many problems in the fields both of distillation of the shales and treatment and refining of the oils remain yet to be solved, but these problems are considered to be comparatively simple of solution and are now being studied.

Wider Use of Cracking Processes

From the point of view of the oil refiner the most desirable way of increasing the supply is to get more of it from the same quantity of crude oil now refined. This can be accomplished either by extending the range of volatility acceptable for fuels or by the employment of methods that increase the quantity of volatile products obtainable from the crude. The latter possibility is that which the use of the cracking process covers. The development of these processes is today the most important field of experimentation in the industry and considerable progress has already been made. The Burton process, owned and controlled by the Standard Oil Company of Indiana, and operated by various of the companies of the Standard group, has been developed to a high degree of efficiency and is regularly converting large quantities of heavy petroleum distillates into satisfactory fuel.

The Hall process, which is said to be operated on a large scale in England and to some degree in the United States, is also apparently in the stage of successful commercial operation. The Rittman process, with which the Bureau of Mines has been largely concerned, seems now to be thoroughly developed for the large scale production of gasoline and should soon be a commercial factor in the market. Other processes now operating are the Greenstreet and the Cosden.

At present it appears that the Burton process and others of the pressure distillation type can operate successfully using as raw material fairly heavy petroleum distillates, such as the fuel and gas oil types. The Burton process cracks a limited amount of kerosene also but it is not adapted in its present stage of mechanical development to the treatment of oils of this type. The Rittman and Hall processes are said to operate equally well with kerosene and the heavier distillates. The Greenstreet process seems to operate entirely with kerosene distillate. It is not known that any pressure cracking process is successfully utilizing oils of the residuum type in large-scale apparatus. These crack readily enough but the mechanical difficulties incident to the deposition of large quantities of carbon have so far interfered with commercial success.

Profitable Cracking Difficult

The general consensus of opinion of those qualified to judge is that the production of volatile hydrocarbons, satisfactory for use as fuel, can be brought about by many modifications of the principle of applying heat and pressure but that the cracking process in general cannot be made a commercial success unless handled with a high degree of scientific and technical skill and under carefully regulated economic conditions. In other words, although oil is easy to crack it is not easy to crack profitably. The oil cracking art is in many ways like the poultry business. Any amateur can convert grain and meat scraps into chickens and eggs but it takes more than interest and ambition to accompany this process by the accumulation of financial profit. Likewise, it is tolerably easy to make gasoline out of heavy oil but a totally different matter to keep the cost of the finished product satisfactorily below its market price.

It appears therefore that although the cracking process offers great possibilities of increase in the supply of fuel, this increase is bound to be in the way of a gradual development and in no way revolutionary. It is possible that if cracking processes were used to the full extent of their applicability the total production of gasoline from the quantity of crude oil now produced might be doubled. This increase cannot however be expected on the basis of reasonable possibility in less than ten years.

An adequate discussion of cracking processes would require more time than automotive engineers would wish to devote to even this vital subject and for the present the situation can be summarized by stating that this method of increasing the fuel supply seems just at present to be considerably more important than any or all of the possibilities already discussed.

Use of Heavier Petroleum Distillates

The possibilities of increasing our future supply of fuel have already been discussed from the points of views of several industrial divisions. It has been shown that the men in the producing end of the oil industry may help solve the problem by making available new supplies of crude petroleum. Scientists have the problem of making available the supply obtainable from oil shales.

The coal distillation and the fermentation industries may in the future supply greater or less quantities, and the refiners by the improvement of their present methods and the development of cracking processes can contribute enormously to the country's production. There remains for discussion the part that designers and builders of internal combustion engines have to play in increasing the potential supplies.

Increase in Engine Efficiency

It may seem presumptuous for a rank outsider in the gasoline engine business to suggest that one of the most important lines of activity for automotive engineers is to increase the potential efficiency of the engines they turn out. It actually seems, however, that there are tremendous possibilities in this line, not necessarily through increases in mechanical efficiency, but by educating the public to demand and use automobiles that are essentially economical in consumption of fuel. There are now on the market types of cars that on average roads and grades can travel about 20 miles on a gallon of gasoline. Most of these cars are of low and moderate price and it appears that the majority of higher priced cars get notably less mileage, this in some cases being as low as 6 or 8 miles per gallon.

Such a condition should not continue because if fuel, at any price, is not going to be available, the automobile business is bound to suffer. For this reason it seems that the designers and manufacturers ought to take this matter in their own hands, regardless of the present demands of buyers, and work out a reasonable standard of performance for all cars. For instance, cars might be built with the basic assumption that a two or three-passenger car must travel 22 miles on a gallon of gasoline, a five-passenger car 18 miles and a seven-passenger car 16 miles. Some such standard of efficiency as this should be regarded as ironclad and all automobile design based upon it. Such considerations as speed and hill-climbing power should not be allowed to interfere with this matter of efficiency and the users will soon get over the idea that it is necessary to have 80-hp. engines in their cars

when 30 hp. is sufficient to carry them at adequate speed anywhere they want to go.

Perhaps no phase of the fuel situation has so interested automotive engineers as the use of kerosene in place of gasoline. Present market conditions are such that kerosene is one of the cheaper petroleum products, and as it has already been demonstrated to work satisfactorily in internal combustion engines under certain conditions there has been a great desire to render it available for general use in automobiles. The Bureau of Mines has had called to its attention many devices for the utilization of kerosene but believes that mechanical development in this particular line is a mistake. The logical and reasonable way to utilize kerosene is not as such but as a mixture with the gasoline produced with it in the refining of crude oil. In other words, attention should not be given to the utilization of kerosene but to the utilization of petroleum distillates containing both the gasoline and kerosene fractions of crude oil.

In terms of the testing laboratory this means fuel of high endpoint and correspondingly lowered average volatility. Such fuels could be produced by the refiners with slight modification of their present methods and equipment, and their price should be somewhat less than the average price of gasoline and kerosene now marketed separately. The gain would be the simplification resulting from the production and handling of one instead of two products. The Bureau is not attempting to tell just how the problem of designing engines that can handle fuel of from 550 to 600 deg. fahr. endpoint can be solved, but accomplishment of such an end ought not to be beyond the skill and ingenuity of engine designers, especially as they have already seriously undertaken the infinitely more difficult task of using straight kerosene.

The utilizing in automobile engines of a type of fuel that contains the combined gasoline and kerosene fractions of crude petroleum would certainly double the available supply, and even if all the other agencies working to this end failed the automotive engineers themselves would postpone for a long time the fateful day when their industry will be handicapped by not having available the material to feed engines after they have been produced.

Author's Conclusion

The present paper has developed along rather heterogeneous lines but can be summarized rather simply. The present fuel situation, in spite of the fact that gasoline is high in price and relatively low in volatility, is good. This will be appreciated more fully if war conditions add one more inconvenience to the already lengthy list that the country is experiencing. The newer types of gasolines are not inherently worse than the old; the price is not out of proportion to the price of crude petroleum, and the supply is abundant and well distributed.

In the future it appears that oil producers must secure more crude petroleum and refiners must get greater yields of volatile products from the oil treated. Designers must work toward higher standards of fuel economy and must strive to develop engines that will handle fuels of lower average volatility than the present type. A certain increase in supply of fuel may be counted on from the coal distillation industry and eventually the supply may be derived either from oil shale or from fermentation industries.

In closing it is desired to remind the members of the Society of Automotive Engineers that the present paper makes no pretense of being a last word on the important subject with which it deals. The various phases of the fuel situation could be discussed at almost infinite length and it is realized that even the few problems mentioned in this paper have not been given the detailed consideration they deserve. It is hoped, however, that the attention of the engineers of the Society may have been called to some problems that they can profitably study.

ITALY'S TRIBUTE TO THE SOCIETY

The following extracts from a communication sent by Major General P. Tozzi, chief of all the Italian Military Missions in the United States, are an eloquent testimonial to the spirit displayed at the Annual Dinner of the Society.

"In the first place, it behooves me to offer, both as an Italian and for myself personally, the warmest and sincerest expressions of my gratitude for the splendid tribute which the members and guests of the Society paid to Italy when the Toastmaster of the evening referred with glowing, unforgettable words of praise to that member of the allied family. The joy and pride which we members of the Italian Military Mission felt while those words were being uttered were mixed with a keen desire that every true Italian might hear and be cheered by them.

"But if that desire must remain, in its literal conception, a dream of patriotic hearts, we who were privileged to hear those words must necessarily feel like the spokesmen of the many Italians who did not hear them, but who are from day to day made increasingly aware of the spirit of fellowship and of cooperation which binds this young and powerful Republic to our beloved Land.

"These two countries were truly made to understand, help, and complete each other. The one ancient, experienced in the ways of civilization, again and again the leader in the World race for supremacy in Art, in Law, in Government, in Discovery; yet never willing to rest satisfied with past achievements, ever ready to rise from political oppression and enforced degradation and scientific obscurity and mental torpor, and to say to History: I am here, I am ripe for resurrection, I am immortal. The other, young yet fully developed, eldest of the group of sister Republics of the New World, eager to learn, anxious to adapt what she has learned, and after adding to it the ripe fruit of her magnificent inventiveness, willing to hand it over to the rest of the world, stamped with the indelible mark of her originality and unsurpassed practicality.

"These were the reflections which occupied my mind while your Toastmaster and the speakers who followed him were so eloquently referring to the interchange of mental achievements between our respective countries, to this stupendous give-and-take between lands whose scientific interweaving was only preparatory to the present politico-military interweaving aimed at the downfall of the common foe.

"Created today under such lofty auspices, cemented tomorrow by the sacred offering of so much pure Allied blood poured upon the altar of Freedom in a wartime spirit of free giving and of unlimited, smiling, willing sacrifice, the cornerstone which Italy and the United States of America bring and lay together today will form no mean part of the structure that will rise tomorrow upon the ruins of a World that was."

Heat-Flow Through Cylinder Walls

By Louis Illmer* (*Member of the Society*)

Annual Meeting Paper. *Illustrated with* Charts

THIS paper is a research study into speed limitations imposed upon internal combustion engines by excessive heat-flow through jacketed cylinder-walls. Modern requirements have already forced the rotative speed of high-duty gas and oil engines to a point where the difficulty of heat-flow control, especially with cast-iron cylinders, tends to arrest further progress in this direction.

In view of this inherent limitation the art of high-speed engine design can best be advanced, not by continued experimental exploration, but rather by first establishing the basic principles underlying heat-flow effects.

The purpose of the present paper is to demonstrate that every internal-combustion engine of given size and type has a safe speed limit and that this can be predetermined upon a rational heat-flow basis. This paper provides an explicit method of procedure, by means of which the design characteristics of a normal gas or oil engine can be critically analyzed for heat-flow effects.

In addition, the matter of relative heat-flow in two versus four-stroke cycle engines, which has been the subject of much controversy, is investigated and certain conclusions are drawn as to the merits of each type.

Introduction

The fixing of a suitable margin of safety for a steam-engine cylinder is a comparatively simple matter when the working pressure and strength of material are known. In the case of gas-engine cylinders, on the other hand, the stress relations become more involved because of the additional temperature stresses set up by heat-flow through the cylinder walls. The faster the engine speed, the greater will be the temperature stress produced.

This paper undertakes to analyze the combined pressure and temperature stresses in gas-engine cylinder walls and to prescribe the limiting stresses and extreme engine speeds that will insure satisfactory operation. The method pursued is that of fixing the maximum allowable rate of heat-flow into the jacketed walls of any given cylinder from jacket-loss determinations.

The two principal factors that impose restriction upon rotative speeds are excess heat-flow and undue inertia pressures. This paper will deal entirely with the thermal aspects of such limitations, since the inertia effects can usually be kept within bounds by suitable construction.

A considerable number of the available jacket-loss tests have been analyzed for heat-flow data, but few if any investigators report all their data in the detailed form desired for present purposes. No one of such tests was conducted throughout a sufficiently wide range of conditions to define fully the controlling factors of heat-flow. It was necessary therefore to pick out portions of data furnished by different experimenters and to work for a composite result. The conclusions thus drawn are thought to be sufficiently accurate to fix the speed limitations imposed by excess heat-flow, and to indicate means by which its destructive effect can be minimized.

Furthermore, this analysis of jacket-loss tests has been supplemented by a study into the speed-limits of engines as used for various kinds of commercial services. By collecting a sufficiently large amount of such data, a fairly satisfactory value was determined for the limiting rotative and piston speed for each particular kind of engine. Finally, by combining these separate constants on the basis of the heat-flow laws deduced from jacket-loss tests, it was possible to arrive at a basic formula for speed limits, applicable to small high-speed engines as well as to large slow-speed engines of maximum output.

Synopsis of Heat-Flow Formulas

For the sake of a clearer presentation, certain conclusions will be briefly reviewed before citing the data upon which the given heat-flow rate has been based.

As found by the methods described, three principal factors control heat-flow through the jacketed cylinder-walls of internal combustion engines, and these can be expressed thus:

$$H = C_f \left(\frac{MEP}{E}\right)^{4/3} \frac{N}{\log_{10} N} F^{2/3} \qquad (1)$$

where H = uniformly distributed full-load heat-flow through the jacketed cylinder-wall as measured in B.t.u. per hour per sq. in. effective cooling surface A_e.

C_f = constant depending upon the cycle of the engine.

MEP = mean effective pressure, lb. per sq. in.

E = thermal efficiency as indicated in the power cylinder.

N = engine speed, r. p. m.

$\log_{10} N$ = common logarithm of N.

F = surface factor, that is, effective volume V_e in cu. in., divided by the effective surface A_e in sq. in., as measured with the piston standing at one-fourth stroke from its inner dead-center position.

As given, (1) is intended to apply only to engines operating at or near rated capacity. It will be seen that heat-flow is largely dependent upon the factor MEP/E, which in turn is determined by the heat-input per cubic foot of piston displacement, thus:

$$\text{Heat input/cu. ft. displ.} = \frac{144\,MEP}{778\,E} = 0.185\,\frac{MEP}{E} \qquad (2)$$

The heat-input measures the temperature rise occurring in the working charge during the explosion period. Furthermore, the ratio MEP/E can, without serious error, be used to approximate the average temperature of expansion; for explosive engines its value usually lies between 8 and 10, and averages about $9MEP/E$.

The first factor of (1) can be considered as the temperature factor of heat-flow. The value of the exponent k of the factor $(MEP/E)^k$ is found to lie between 5/4 and 3/2, with the given value of 4/3 as a fair average for full-load conditions.

Thus, the rate at which heat flows from the hot working charge into the surrounding cylinder wall is found to be dependent in part upon the average temperature head maintained during the expansion stroke as measured with respect to the absorbing jacketed wall, and partly, in the

*Gas and Oil-Engine Expert, Milford, Conn.

author's opinion, upon the greater thermal conductivity of the working charge at high temperature.*

The absorption of heat during the suction and compression strokes of a four-stroke-cycle engine can be taken as negligible. The comparatively small jacket loss occurring during the exhaust stroke is most conveniently taken in terms of the heat loss of the expansion period.

The second factor $N/\log_{10}N$ of (1) is a time factor. The time of action for a single explosion is measured in terms of $1/N$ minutes, but its relative effect in driving heat into the cylinder jacket is found to be proportional to $1/\log N$.

The speed of 10 r.p.m. has been selected as a convenient unit of time reference. Thus, at 1000 r.p.m. the relative heat-absorbing capacity per cycle of a given cooling surface is about one-third that at 10 r.p.m. The cyclic heat-absorbing capacity multiplied by the number of temperature applications N provides a measure for the total heat-flow into the cylinder wall, in so far as speed effects are concerned.

The last factor F of (1) is the surface factor. When a small surface surrounds a large volume, the rate at which heat will be given off to a unit surface must necessarily be more intense than from a small volume enclosed by a relatively large surface.

The variation in jacket loss that occurs with change in the surface condition can be taken care of by the surface factor F, as indicated in (1). The numerical value of F is dependent upon the shape and dimensions of the combustion chamber, and for similarly built engines it increases directly with the cylinder-bore dimension.

In determining the cubic content per unit of surface, not only must the enclosing head and piston surface be taken into account, but, to arrive at a correct value for the total effective cooling surface of the cylinder parts, a certain portion of the bore surface should also be included. Since all parts of the bore surface do not absorb heat from the working charge at the same rate per unit of exposed surface, the total cooling effect of the bore wall can conveniently be expressed in terms of an equivalent surface having the same rate of heat flow as the initial clearance surface.

Further experimental evidence is required to determine such a bore allowance accurately, but from an analysis of the available data, it appears that about one-fourth of the cylinder-bore surface can be taken as a fair allowance for this added cooling effect. Accordingly, the surface factor F is to be measured by dividing the clearance volume plus one-fourth the piston displacement by the sum of the initial clearance surface and one-fourth of the bore surface, that is, V_e/A_e.

Order of Treatment

The further discussion of this subject will be treated under the following headings:

(A) Jacket-loss test data from which (1) was deduced.

(B) Temperature stresses set up in cylinder walls by heat-flow.

(C) Pressure stresses produced within cylinder walls by the explosive pressure.

(D) Bore temperature formulas as based upon the temperature head required to drive a stipulated heat-flow through the cylinder wall and into the surrounding jacket-water.

(E) Rotative-speed limits as determined from engines in commercial service.

(F) Bore-temperature limits as deduced from engines in commercial operation.

(G) Formulas for the minimum cylinder thicknesses applicable to high-speed engines.

(H) Allowable heat-flow constants as based upon the prescribed bore-temperature limits.

(I) Formulas for the surface factor F.

(J) Limiting speed formulas for low-compression gas and oil engines as deduced for the prescribed bore-temperature limits.

(K) Two versus four-stroke-cycle engines as viewed from the standpoint of heat-flow effects.

(L) Formulas for jacket-loss as measured in terms of heat input.

(M) Constancy of indicated efficiency with increasing jacket-loss.

(N) Importance of small surface factors and the advantages accruing from adequate cooling surfaces, especially for large engines.

(O) Recapitulation or conclusion.

Analysis of Jacket-Loss Test-Data

The jacket-loss tests made in an experimental research study by Gibson and Walker† provide the most suitable data with which to determine the first two factors of (1). These tests apply to a National 11 by 19-in. single-acting four-stroke cycle gas engine, arranged to alter the compression ratio between the limits 5.17, 5.70 and 6.62. The engine speed was also varied from 150 to 250 r.p.m.

The constructive features of this engine proved to be well adapted for consistent jacket-loss determinations. The cylinder head is cast integral with the cylinder proper, but the jacket space is divided into two compartments, one of which surrounds the exhaust passage. By this means it was possible to separate the exhaust loss and to compute the jacket loss during the expansion stroke up to the point of release.

As the cited reference does not record all the desired data in a form best suited for present purposes, it has been necessary to interpolate a portion of the data, giving the results shown in Table I. The heat input has been estimated on the basis of (2), and when multiplied by the given jacket-loss percentage measures the gross heat-flow through the cylinder walls.

Although three sets of tests were made at the specified expansion ratios, the range of these experiments proved too close to bring out definitely the effect upon heat-flow of change in the expansion ratio R. Hence Table I analyzes only one of these tests, namely, that for $R = 5.7$. The agreement between the given empirical relations and the experimental data are thought to be sufficiently close to establish the first two factors of (1).

Surface Factors

Owing to the limited test data, it has been more difficult to arrive at an entirely satisfactory mode of treatment for surface effect.

Granting the correctness of the first two factors of (1),

*According to O. E. Meyer's "Kinetische Theorie der Gase," the thermal conductivity of a gas at high temperature can be expected to increase in the same ratio as does the product of coefficient of internal friction (viscosity) and its specific heat. Assuming the latter to remain constant, the themal conductivity of air, for instance, as based upon Barus' viscosity experiments, is found to be about 4/3 larger at 3000 than at 2000 deg. fahr.; hence, within the usual range of expansion temperatures, the conductivity of air changes approximately as the two-thirds power of the temperature increase. While the corresponding conductivity factor, as fixed for internal-combustion engines by (1), increases at a somewhat slower rate, this difference is no doubt chargeable to the altered character of the working charge and the approximate method used for estimating temperatures.

†Inst. of Mechan. Engrs., May, 1915. Distribution of Heat in the Cylinder of a Gas-Engine.

TABLE I—ANALYSIS OF JACKET-LOSS TEST-DATA

B.HP., Full Load	N R.p.m.	Air to Gas Ratio	MEP Lb./Sq.In.	Ind. Eff. E (%)	$\frac{MEP}{E}$	% Jacket Loss, J*	Heat-Flow, H*	$H \div \left(\frac{MEP}{E}\right)^{4/5}$		Constant Cf*
25.0	150	1:7	82.8	32.8	252	27.0	148	0.0932		
20.0	150	1:9	69.5	34.1	204	25.3	112	0.0933	0.0925	0.000822
16.5	150	1:11	61.1	34.1	179	23.5	92	0.0911		
31.5	200	1:7	81.9	33.5	244	25.3	179	0.117		
25.0	200	1:9	67.8	34.9	194	23.5	132	0.117	0.116	0.000818
20.5	200	1:11	58.6	34.9	168	21.5	105	0.113		
36.0	250	1:7	80.5	33.8	238	24.5	212	0.143		
28.5	250	1:9	67.3	35.4	190	22.8	157	0.144	0.141	0.000828
23.5	250	1:11	57.8	35.4	163	20.7	122	0.137		

*Jacket loss in terms of heat-input as measured to the end of expansion stroke equals about 80 per cent of total jacket loss.
Effective cooling surface Ae = about 400 sq. in.
Surface factor F = about 2.09.

an allowance for surface effect can be determined by analyzing a series of jacket-loss tests as made upon similar engines of widely different dimensions. The most suitable data that the author has been able to find for this purpose apply to some old-style low-compression four-stroke cycle Deutz gas-engines.*

The results, set forth in Table II, show that the heat-flow per unit of effective cooling surface does increase to a marked degree with increased cylinder dimensions. On the basis of this and other data, the exponent n of the

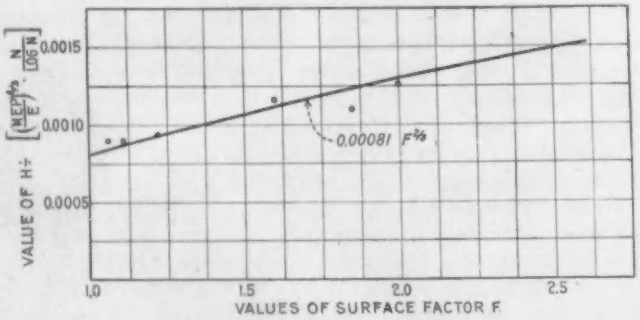


FIG. 1—CURVE SHOWING SURFACE EFFECT

factor F^n has been placed at 2/3, as given in (1) and plotted in Fig. 1.

Equivalent Surface Allowance for Cylinder Bore

The equivalent surface allowance that should be added to the clearance surface in order to allow for the cooling effect contributed by the cylinder bore can be found by working with an engine having provision for an extended change in the ratio of expansion. The most serviceable test for this purpose appears to be that made by Prof. F. W. Burstall.† This was made upon a 16 by 24-in. single-acting horizontal four-stroke cycle Premier gas-engine running at 170 r.p.m., with provision to change the ratio of expansions from 4.27 to 8.07. Furthermore, the exposed clearance surfaces are fully specified.

This engine was provided with a separate flat cylinder head bolted to a massive internal-jacket flange, thus forming the combustion chamber in an extended portion of the cylinder bore. The jacket losses appertaining to the head and the cylinder jacket, as well as to the water-cooled piston and valves, are reported separately.

In this test the head jacket shows a disproportionate percentage of jacket loss when measured in relation to its cooling surface, but this is probably due to the massive cylinder flange and the considerable conductive power of the cylinder-head studs. To use this test to advantage, it has been deemed advisable to work with average values of the given total jacket losses and to group the tests as indicated in Table III.

TABLE II—ANALYSIS FOR SURFACE EFFECT

Rated B.Hp. per Cyl.	3	3	4	8	12	16	25
Bore, in.	6.1	6.75	6.75	9.1	10.6	11.4	13.0
Stroke, in.	12.2	10.2	13.4	15.7	17.7	20.4	26.0
Rev. per min., N	182	178	160	159	140	141	139
Jacket loss, J, per cent	52.0	54.0	49.5	47.6	39.4	40.8	43.0
$M.E.P.$, lb./sq. in.	42.3	42.2	45.0	44.5	44.6	49.4	50.0
Ind. eff., E, per cent	18.2	18.4	20.3	19.9	20.7	22.4	23.7
MEP/E	232	229	222	228	215	220	211
Surface factor F, about	1.11	1.06	1.22	1.60	1.85	2.0	2.37
Heat-flow H, about	94	94.5	84	107	85	101	118
$H \div \left[\left(\frac{MEP}{E}\right)^{4/5} \frac{N}{Log\,N}\right]$	0.00090	0.00090	0.00094	0.00116	0.00110	0.00126	0.00157
Constant Cf	0.00084	0.00088	0.00083	0.00085	0.00073	0.00079	0.00090

The equivalent bore surface allowance can be found on the assumption that the heat-flow constant C_f applying to the respective cooling surfaces A_e must be about the same for each one of the different expansion ratios used. As shown in Table III, this condition is best satisfied when the equivalent bore-surface allowance is taken as constant, namely, at $\pi DL/4$, the bore and stroke being D and L, respectively.

An estimate of this bore-surface allowance can also be made by using equal crank angles as a measure of time, and then integrating the product of the respective time, temperature and surface factors corresponding to each such crank position. The resulting value for the

TABLE III—CHECK FOR BORE SURFACE ALLOWANCE

Test No.	N R.p.m.	Compression		M.E.P. Lb./Sq. In.	Ind. Eff. E (%)	$\frac{MEP}{E}$	Jacket Loss		Surface Ae, Sq. In.	Surface Factor F	Heat-Flow H	Constant Cf
		Lb.-Gage	Ratio R				Per Cent Input J	B.t.u. per Min.				
A & B	168	207	7.86	84	39.6	212	19.7	1802	896	2.13	121	0.00078
C	170	173	7.22	92	41.5	222	20.6	2012	913	2.18	132	0.00078
D	171	157	6.79	98	40.4	243	19.5	2108	927	2.19	138	0.00070
F	169	132	6.20	101	35.9	281	20.2	2633	952	2.24	166	0.00070
J	167	127	5.45	94	34.5	272	28.6	3311	971	2.35	205	0.00088
Q	168	88	4.36	87	30.0	290	27.4	3453	1077	2.45	193	0.00074

*Brauer, Z. d. V. D. Ing., 1887.

†Third Gas-Engine Research Committee Report, Proc. Inst. of Mech. Engrs., Jan., 1908.

equivalent bore allowance is somewhat larger than that determined upon the experimental basis.

While the available experimental data are not sufficiently complete to furnish conclusive evidence as to the exact laws for the surface influence, the described procedure does allow of drawing some important conclusions as to the manner in which heat-flow can be expected to affect speed limitation. It will now be shown that the formulas deduced give reasonably consistent results when applied to engine jacket-loss tests covering a wide range of conditions.

Engine Jacket-Loss Analyses

A set of variable speed tests showing the application of the principles deduced was conducted by Prof. W. T. Fishleigh and W. E. Lay* upon a 4⅛ by 5¼-in. four-stroke cycle six-cylinder L-head automobile engine. The check results are presented in Table IV.

TABLE IV—AUTOMOBILE ENGINE JACKET TEST—F=ABOUT 0.6

N R.p.m.	Approx. MEP, Lb./Sq. In.	Ind. Eff. (E), per Cent	MEP / E	Per Cent Jacket Loss: To Water	Per Cent Jacket Loss: To Fan	Heat Flow H	Constant CF	
640	41	19.3	212	40	20	260	0.0009	
640	67	22.1	303	40	19	390	0.0012	
1000	42	18.5	227	31	18	372	0.0008	0.00095
1000	68	19.6	346	28	15	502	0.0009	
1350	44	19.6	224	29	25	557	0.0010	
1350	70	19.9	351	24	18	687	0.0009	

Applying these check principles to large gas engines, Gueldner† cites a number of tests that confirm the general deductions embodied in (1). Tests taken from this source are analyzed in Table V.

TABLE V—LARGE GAS-ENGINE JACKET-TESTS—S. A. FOUR-STROKE

	Westinghouse 13x14	Westinghouse 25x30	Deutz 15x22⅞	Crossley 11½x21
R.p.m., N	258	150	205	180
MEP, lb./sq. in.	83	75	67.2	102
Ind. eff. E, per cent	25.5	27.4	29.5	34.5
MEP/E	325	274	240	296
Jacket loss, J, per cent	32.1	33.3	35.5	....
Heat-flow, H	425	255	211	190
Surface factor, F	2.4	2.9	2.0	1.7
Constant CF	0.00099	0.00102	0.0012	0.00085

A further test, as made by Professor Hopkinson‡ upon a 11½ by 21-in. single-acting four-stroke cycle Crossley gas engine, running at 180 r.p.m., is also analyzed in Table V. This test is of special interest because the heat-flow into the non-cooled piston head was experimentally determined by means of its temperature gradient. The estimated heat-flow H into the cylinder walls of this engine, as given in Table V, is found to be about 4/3 larger than the determined rate of heat-flow into the piston head. About one-half of such retardation in heat-flow can be ascribed to the higher counter-temperature of the piston face, and the other half is probably due to the relatively weaker explosive mixture lying adjacent to the piston face. This restricted heat-flow has been allowed for in working out the accompanying tables by taking the equivalent effective piston area for single-acting non-cooled pistons at three-fourth actual area.

*Heat Balance Tests of Automobile Engines. Part I, Vol. 10, S. A. E. Transactions.
†Internal Combustion Engines. Trans. by Prof. H. Diederichs.
‡Proc. Inst. of Civil Engrs., February, 1909, on Heat Flow and Temperature Distribution in the Gas-Engine.

For the sake of comparison, similar checks have been made for heat-flow through the cylinder walls of single-acting four-stroke cycle Diesel oil engines. The data shown in Table VI have been taken from various sources.** It appears that, notwithstanding the con-

TABLE VI—ANALYSIS OF DIESEL ENGINE JACKET-LOSS TESTS

Make of Engine	Amer. Diesel	Augsburg	Augsburg	Carel's	British Diesel	Amer. Diesel
Size, Inches	10¼x16½	9⅞x15⅝	6½x10⅝	22x29½	26x29½	16x24
N, r.p.m.	192	154	256	153	150	167
MEP, lb./sq. in.	87.6	105	103	99	95	81
Ind. eff. E, per cent	33.9	34.2	40.6	41	39.3	30.4
MEP/E	259	307	254	242	242	266
Jacket loss, J, per cent	.....	.....	21	21.5	22.1	26.2
Heat-flow, H	205	221	194	215	211	214
Surface factor, F	1.4	1.3	0.9	2.6	2.9	1.8
Constant Cf	0.0012	0.00126	0.0012	0.0011	0.0010	0.0011

trolled combustion, the heat-flow through Diesel engine cylinder-walls can be treated in substantially the same manner as for explosive engines.

Summary of Jacket Test Constants

A considerable variation in the value of the constant C_f is to be expected from experimental data taken haphazard and without sufficient detailed information to allow of an accurate evaluation of the surface factor F. The given formulas are sufficiently comprehensive, however, to cover a wide range of engine sizes, as is shown by the following summary:

Table I	Average C_f	= 0.00103	for F	= 2.09
Table IV		= 0.00095		= 0.6
Table V		= 0.00102		= 1.7 to 2.9

The average constant C_f as given above is derived from the total jacket loss. Of this about 10 per cent is a fair allowance for the relative heat-loss occurring during the exhaust stroke of a four-stroke cycle engine, while the jacket around the exhaust passage can be expected to absorb an additional 8 to 12 per cent of the gross jacket loss.

The exhaust-passage jacket-heat does not pass through the cylinder or head walls, but in order to allow for contingencies, the value of the effective heat-flow H for a four-stroke cycle engine will be fixed at:

$$H = 0.001\left(\frac{MEP}{E}\right)^{4/3}\frac{N}{\log_{10}N}\;F^{2/3} \qquad (3)$$

The corresponding value of the constant C_f that applies to two-stroke cycle engines is readily deduced from the following considerations:

Doubling the number of explosions affects only the log factor of (1), and this can be allowed for by increasing the constant to 16/9 C_f. Deducting 10 per cent from the four-stroke constant as an approximate allowance for the heat loss occurring during the exhaust stroke, the corresponding constant for two-stroke cycle engines becomes equal to 0.0009 × 16/9, thus:

$$H = 0.0016\left(\frac{MEP}{E}\right)^{4/3}\frac{N}{\log_{10}N}\;F^{2/3} \qquad (4)$$

Accordingly, the heat-loss of a four-stroke cycle engine is about ⅝ that of a two-stroke cycle engine for identical speed, temperature and surface factors.

Comparatively few two-stroke jacket-loss tests are available with which to check the newly-found value of

**Catalogue of the American Diesel Engine Co., Inst. Naval Architects, 1914. Chalkley "Diesel Engines for Land and Marine Purposes." Jour. Am. Soc. Naval Engrs., November, 1905.

C_f as given in (4). Some commercial tests made upon a 20 by 36-in. double-acting two-stroke cycle engine of the author's design work out to $C_f = 0.0015$, as based upon the total head-end and crank-end jacket-losses. Tests made upon a large Oechelhauser gas-engine, as reported by Prof. E. Meyer, show a check value slightly below that given in (4). Hence the ascribed value for C_f should amply cover the heat-flow for two-stroke cycle engines.

Owing to the perceptible loss of stroke resulting from piston-controlled exhaust ports, the equivalent bore allowance for two-stroke cycle engines should be determined on the basis of the effective stroke when working out numerical values for the surface factor F. For single-acting engines of this type, the effective stroke becomes equal to about ⅞ L.

Temperature Stresses

Having fixed upon suitable values for the heat-flow through the cylinder wall, an estimate can now be made of the resulting temperature stress. The temperature gradient set up by the heat-flow H passing through a cast-iron cylinder-wall can be taken as:

$$t_g = \frac{H}{K} = \frac{H}{3.1} \qquad (5)$$

where t_g = temperature gradient, or drop in deg. fahr., per inch of metal thickness.

K = specific thermal conductivity of the cylinder metal per inch of thickness in B.t.u. per hr. per sq. in. of section at 1 deg. fahr. head,

= about 3.1 for cast iron at normal bore temperature.

Accordingly, the temperature drop due to heat-flow through a cylinder-wall of thickness S is equal to:

$$t_d = t_g S \qquad (6)$$

where S = uniform thickness of head or bore wall in inches,

t_d = total temperature drop in deg. fahr. through the cylinder wall.

Hence, when the wall of an engine cylinder is subjected to a heat-flow equal to H, the temperature assumed by the interior surface will be t_d degrees higher than the exterior surface. This temperature difference produces a compression stress at the interior surface of the bore wall approximately equal to the tension stress set up at the exterior surface, thus:

$$f_t = \frac{t_d}{2} eM = \frac{t_d}{2} \times 0.000006 \times 13{,}000{,}000 \qquad (7)$$
$$= \text{about } 40 t_d.$$

where f_t = temperature stress in lb. per sq. in., set up by the heat flow H.

e = coefficient of linear expansion for hard cast iron.

M = modulus of elasticity for hard cast iron at stress of about 8000 to 9000 lb. per sq. in.

Pressure Stresses

The cylinder wall is also subjected to a pressure stress, which, when added to the temperature stress f_t, gives the total stress. The combined tension stress must not be allowed to exceed certain well defined limits, otherwise fatigue of material will result.

The tension stress resulting from the explosive pressure is not distributed quite uniformly over the entire wall thickness, but as shown by Clavarino's formula,* the stress at the outer surface is somewhat lower. As based upon this formula, the tension stress at the exterior surface of a cylinder under internal explosive pressure can be taken as

$$= \frac{5}{12} \, \frac{P}{\frac{S}{D} + \left(\frac{S}{D}\right)^2}$$

Multiplying this by a shock factor of 4/3, the desired tension stress due to the explosive pressure can be found from

$$f_p = \frac{0.56P}{\frac{S}{D} + \left(\frac{S}{D}\right)^2} \qquad (8)$$

where f_p = pressure stress, lb. per sq. in., at the exterior cylinder surface.

P = explosive pressure, lb. per sq. in.

S = uniform thickness of the cylinder wall, inches.

D = cylinder bore, inches.

The total tension stress produced by the combined action of the temperature and pressure effects is measured by the sum $f_t + f_p$.

According to Stromeyer's tests,† a fully reversing load producing a stress of ± 9000 lb. per square inch can be indefinitely repeated upon a good grade of cast iron without producing any serious fatigue effects. For the limited cylinder stress range of $+f_t$ to $+(f_t + f_p)$, a good sound cast iron cylinder should therefore withstand a stress of, say, 13,500 lb. per square inch. Allowing for a minimum net factor of safety of at least 3/2 as measured with respect to the fatigue limit, this would reduce the maximum allowable working stress to about 9000 lb. per square inch. Whenever possible, and especially for engines that have to pull their rated load continuously for long periods of time, it is advisable to use a net factor of safety of 2, thus reducing the total safe stress limit for $f_t + f_p$ to about 7000 lb. per square inch.

Bore Temperatures

Knowing the temperature drop t_d as fixed by (6), it is now possible to estimate the maximum temperature assumed by the cylinder bore. The rate of heat-flow through the bore surface lying adjacent to the cylinder head is practically identical with that of the head wall itself.

Furthermore, the rate of heat-flow that applies to a gas engine cylinder is far in excess of the usual rate of absorption in steam boilers, which latter rate may be set at from 20 to 40 B.t.u. per square inch per hour. The far greater rate of heat-flow through the cylinder-head wall of a fast running engine, causes the jacket water immediately in contact with its exterior surface to reach a temperature at least equal to that at the boiling point.

In addition, a certain temperature head is required to drive the heat from the head surface into the boiling water. According to Marks,‡ such water takes up about 7 B.t.u. per square inch per hour for every 1 deg. fahr. temperature head as measured with respect to the boiling point. Making due allowance for the various factors noted, the bore surface and interior face of the

*See Merriman: Mechanics of Materials.
†Law of Fatigue—Trans. Inst. Naval Architects, Vol. LVII, 1905.
‡Mechanical Engineers' Handbook.

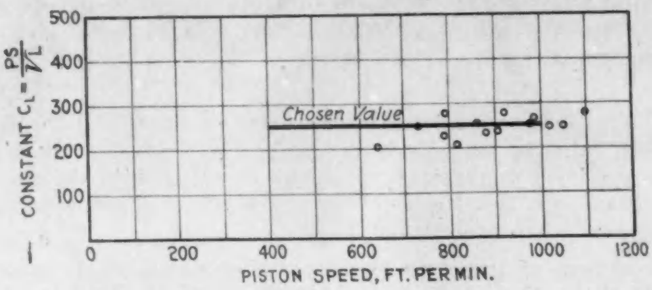


FIG. 2—VALUE OF CONSTANT C_l FOR 2-STROKE CYCLE DIESEL ENGINE

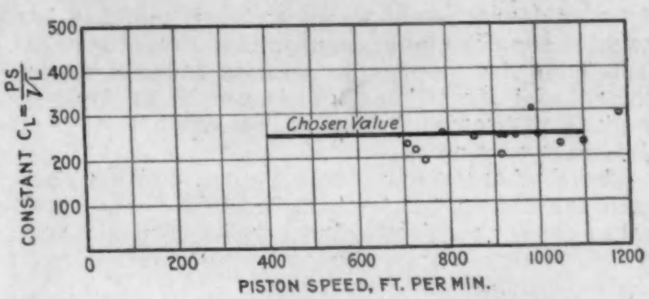


Fig. 3—VALUE OF CONSTANT C_l FOR 4-STROKE CYCLE DIESEL ENGINE

cylinder head wall can be expected to reach a temperature equal to about

$$t_b = 212 + H/7 + (H/3.1 \times S) \qquad (9)$$

where t_b = probable maximum bore-temperature, deg. fahr., as reached in cast iron cylinders.

This equation applies only when the bore metal is uniformly disposed and is effectively water-jacketed throughout. The use of heavy internal cylinder-jacket flanges or any other excessive massing of metal is likely to cause additional localized heating of the cylinder bore.

Rotative Speed Limits from Commercial Engines

Having fixed upon the determining factors controlling heat flow and its effects upon the bore temperature, suitable working limits for these factors can now be found from a study of high-speed commercial engines. The limiting piston speed for any given kind of engine, such as submarine, cargo ship, motorboat, airplane, automobile, stationary and like engines, appears to increase more or less regularly with the stroke dimension. This relation can be approximately expressed by the following simple equation:

$$PS = C_l\sqrt{L} \text{ or } N = \frac{6C_l}{\sqrt{L}} \qquad (10)$$

where $PS = NL/6$ = piston speed, ft. per min.
L = piston stroke, inches.
C_l = piston speed constant dependent upon the type and intended service of the engine.

For any specified service, the allowable piston speed-limit is usually taken as proportional to the square root of the stroke. This investigation has further shown that each of the various kinds of engines has a critical piston speed limit that should not be exceeded for satisfactory operating results.

The value of the constant C_l as found for two and four-stroke cycle submarine Diesel engines are plotted in Figs. 2 and 3 respectively. Other kinds of engines were treated in a similar manner and the values chosen for the representative constant C_l applying to the various engine groups are given in Table VII. The results show reasonably consistent relative values when making due allowance for the limit of cylinder dimensions and intended service of each. The usual range of stroke-bore ratio is also given in the table.

Some interesting results can now be arrived at by analyzing the data in Table VII for heat-flow effects. As will be shown presently, the larger sizes of high-speed engines suffer considerably more from heat-flow effects than do the small fast running engines. The stroke dimension at which heat-flow can be expected to become a deciding factor in speed limitation for any one of the specified kinds of engines can be found by placing its respective piston speed limit equal to $C_l\sqrt{L}$. Then by substituting the corresponding value of C_l as given in Table VII, (10) can be solved for the limiting stroke L.

The accompanying cylinder-bore limits for any particular kind of service can be determined by dividing such stroke limit by a suitable stroke-bore ratio. Table VIII has been determined on this basis and shows the limiting

TABLE VII—COMPARATIVE PISTON SPEED LIMITS

No.	Kind of Engine	Four-Stroke Cycle			Two-Stroke Cycle		
		$PS=Cl\sqrt{L}$	*PS lim.* Ft./Min.	L/D	$PS=Cl\sqrt{L}$	*PS lim.* Ft./Min.	L/D
	GAS AND GASOLINE ENGINES						
A	S. A. stationary, horizontal	$160\sqrt{L}$	800	1¼–1½	$125\sqrt{L}$	600	1⅛–1⅝
B	Double-acting stationary	....	800	1¼–1½	....	720	1½–1¾
C	Small marine, heavy duty	$200\sqrt{L}$	750	1¼–1½	$200\sqrt{L}$	500	1 –1⅛
D	Small marine, high duty	$300–500\sqrt{L}$	1500	1⅛–1½	$250\sqrt{L}$	650	1 –1⅛
E	Small marine, racing	$1000–1200\sqrt{L}$	3000	1½–1¾			
F	Airplane, direct-connected	$500–550\sqrt{L}$	1400	1¼–1½	$500\sqrt{L}$	1100	1
G	Airplane, gear reduction	$850\sqrt{L}$	2200	1½			
H	Motorcycle	$800\sqrt{L}$	1500	1⅛	$500\sqrt{L}$	700	⅞
I	Four-cyl. automobile, moderate speed	$550\sqrt{L}$	1500	1¼–1½			
J	Twelve-cyl. automobile, high speed	$1100\sqrt{L}$	2500	1⅔			
K	Truck and tractor engines	$450\sqrt{L}$	1100	1⅓			
	SINGLE-ACTING OIL ENGINES						
L	High compr., submarine	$250\sqrt{L}$	1100	1 –1⅛	$250\sqrt{L}$	1000	1⅛–1¼
M	High compr., cargo boat	$150\sqrt{L}$	800	1¼–1¾	$140\sqrt{L}$	750	1¼–1⅞
N	Low compr., marine				$190\sqrt{L}$	750	1⅛–1¼
O	High compr., horiz. stationary	$175\sqrt{L}$	900	1¼–1¾	$175\sqrt{L}$	700	1⅛–1½
P	Low compr., horiz. stationary	$175\sqrt{L}$	900	1¼–1¾	$175\sqrt{L}$	700	1⅛–1½

cylinder dimensions at which excessive heat-flow begins to exert a marked influence upon piston speed restriction. This table also specifies the assumed full-load values for the ratio of *MEP/E* for both two and four-stroke cycle engines, with which the rate of heat-flow and other given data have been estimated.

The check results as found for the limiting sizes of such engines are set forth in Table IX. The specified values for the cast-iron cylinder wall thickness S_n are intended to represent average or normal practice and include a customary rebore allowance.

Bore Temperature Limits

By plotting some of the more important data given in Table IX, certain limiting design constants can be deduced for high speed engines. Starting with the bore temperature t_b as fixed by (9) and plotted in Fig. 4, the steady rise of the bore temperature t_b with increased heat-flow shows this to be one of the principal factors in speed limitation. As found from this curve, the maximum allowable temperature that can still be expected to insure satisfactory piston lubrication is

$$t_b \text{ lim.} = 350 + H/10 \text{ deg. fahr.} \qquad (11)$$

Fig. 4 shows a bore temperature of from 400 to 450 deg. fahr. to be a desirable limit. In fast running engines it is apparently necessary to work with an even hotter bore, but the total wall stress $f_p + f_t$ should not be allowed to exceed the prescribed limits.

In case of explosive engines, hot spots in the cylinder must also be guarded against; otherwise preignition is likely to result. While this restriction does not apply to oil engines with timed injection, the plotted bore temperatures for both two and four-stroke cycle oil engines are almost identical with those of explosive engines. The bore temperature can therefore be taken as the primary factor in fixing rotative speed limits, provided that the valves and head parts are kept under the requisite temperature control by adequate design measures.

Table VIII—Limiting Cylinder Dimensions from Equation 10

No.	Kind of Engine	Four-Stroke Cycle						Two-Stroke Cycle					
		$D \times L$, Inches	N, R.p.m.	MEP, Lb./Sq. In.	Ind. Eff. E, per Cent	$\frac{MEP}{E}$	Jacket Loss J, per Cent	$D \times L$, Inches	N, R.p.m.	MEP, Lb./Sq. In.	Ind. Eff. E, per Cent	$\frac{MEP}{E}$	Jacket Loss J, per Cent
	SINGLE-ACTING GAS AND GASOLINE ENGINES												
A	S. A. stationary, horizontal	19 x25	190	80	30	207	29.3	15 x23	155	65	28	232	21.9
B	Double-acting stationary	23 x30	160	75	30	250	27.1	19 x30	145	70	28	250	20.0
C	Small marine, heavy duty	10 x14	325	85	22	385	44.5	5⅝x 6¼	480	45	18	250	39.0
D	Small marine, high duty	7½x 9	1000	80	22	364	41.3	6¼x 6¾	575	41	17	241	36.3
E	Small marine, racing	5 x 7½	2400	90	25	300	38.3						
F	Airplane, direct-connected	5¼x 7	1200	100	25	400	42.9	5 x 5	1300	60	20	300	33.4
G	Airplane, gear reduction	4½x6¾	1950	100	25	400	41.9						
H	Motorcycle	3¼x 3½	2500	75	20	375	49.0	1¾x 2	2100	40	16	250	46.5
I	Four-cyl. automobile, moderate speed	5½x 7½	1200	80	22	364	43.7						
J	Twelve-cyl. automobile, high speed	3¼x 5	3000	75	20	375	46.4						
K	Truck and tractor engines	4½x 6	1100	80	22	364	47.4						
	SINGLE-ACTING OIL ENGINES												
L	High compr., submarine	17 x19	350	100	38	263	19.6	13 x16	375	95	36	264	15.7
M	High compr., cargo boat	19 x28	170	95	40	237	19.9	17 x28	160	90	38	237	15.4
N	Low compr., marine							13 x15	300	40	21	190	23.5
O	High compr., horiz. stationary	18 x26	210	90	40	225	19.3	12 x16	260	85	38	224	15.9
P	Low compr., horiz. stationary	18 x26	210	50	23.5	217	30.7	12 x16	260	40	21	190	23.3

Table IX—Heat-Flow and Stress Data for Limiting Engine Sizes

No.	Four-Stroke Cycle							Two-Stroke Cycle						
	Surface Factor F	Heat-Flow H	Wall Thickness S_n, In.	Bore Temp. t_b, Deg. F.	Wall Stress, Lb./Sq. In. Press., f_p	Temp., f_t	Total, f_p+f_t	Surface Factor F	Heat-Flow H	Wall Thickness S_n, In.	Bore Temp., t_b, Deg. F.	Wall Stress, Lb./Sq. In. Press., f_p	Temp., f_t	Total, f_p+f_t
	SINGLE ACTING GAS AND GASOLINE ENGINES													
A	2.68	276	1 3/16	358	2930	4240	7170	2.17	269	1	337	2770	3480	6250
B	3.29	252	1 1/8	370	2850	4880	7730	2.79	333	1 1/4	393	2775	5360	8135
C	1.63	505	3/4	406	2080	4880	6960	0.87	336	13/32	304	1700	1760	3460
D	1.14	942	15/32	489	2510	5730	8240	0.96	485	3/8	340	1970	2360	4330
E	0.81	1580	9/32	581	3320	5730	9050							
F	0.82	1010	1/4	438	3920	3280	7200	0.70	1060	1/4	449	2910	3440	6350
G	0.73	1420	7/32	514	3850	4000	7850							
H	0.47	1200	5/16	456	2190	2920	5110	0.28	685	5/16	352	950	1680	2630
I	0.88	930	11/32	448	2090	4120	6210							
J	0.53	1520	5/16	521	2190	3680	5870							
K	0.72	757	5/16	396	2080	3040	5120							
	SINGLE-ACTING OIL ENGINES													
L	1.88	352	1 5/16	427	3050	6600	9650	1.42	498	1 1/8	463	3020	7200	10220
M	2.43	203	1 3/8	364	2540	4920	7460	2.16	283	1 11/16	407	2540	6170	8710
N								1.83	317	3/4	334	2060	3080	5140
O	2.28	215	1 13/16	369	2540	5040	7580	1.37	290	1 1/4	374	2440	4840	7280
P	2.88	239	1 1/8	333	1880	3480	5360	1.78	276	11/16	313	2060	2440	4500

Cylinder-Wall Thickness

The pressure stress f_p as derived from (8) for the limiting engine sizes in Table VIII is found to be approximately equal to

$$f_p = 2000 + PD/10 \qquad (12)$$

The normal cylinder-wall thickness S_n that applies for an explosive pressure of 300 lb. per sq. in. when figured upon the basis of (12), is plotted as curve A in Fig. 5. It is expedient to maintain the pressure stress f_p at the highest allowable value so as to work with the minimum

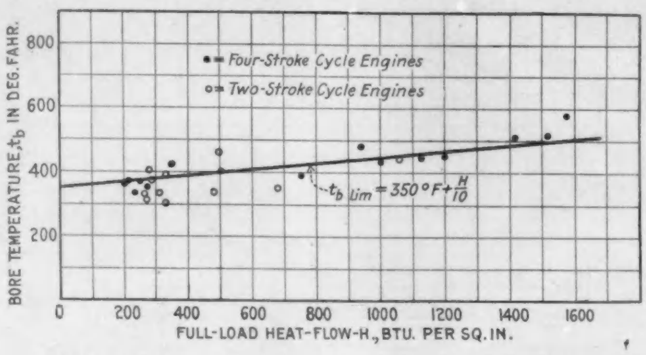


FIG 4—CURVE SHOWING BORE TEMPERATURE LIMITS

combined stress $f_b + f_t$. That the pressure stress specified in (12) can be increased to advantage is apparent from the following considerations:

The minimum safe thickness for a simple thin cylinder as determined solely upon a pressure stress basis is $PD/2 \times 3750$, where the 3750 is the allowable pressure stress for a thin cast iron cylinder of 20,000 lb. per sq. in. ultimate strength at a gross factor of safety of $4 \times 2 \times 4/3$.

If to this a suitable but close rebore allowance be added, we have

$$S_{min} = \frac{PD}{7500} + \frac{\sqrt{D}}{20} \qquad (13)$$

where S_{min} = minimum allowable cylinder-wall thickness in inches.

This formula appears to give satisfactory values throughout a wide range of bore sizes, and in fast running engines can be expected to provide for the minimum total stress $f_p + f_t$. For hard close-grained cast iron, S_{min} can be reduced in proportion to its increased ultimate strength.

For the smaller sizes of slow running engines where no disturbing effects are set up by heat-flow, the use of a cylinder-wall thickness of about $1\frac{1}{4}S_{min}$ provides for stiffer construction, and facilitates the work of casting and machining of the cylinders. Excessive bore allowance is not advisable in high-speed engines, as it tends to augment cracking troubles and thus may defeat the intended purpose of lengthening the cylinder life.

Values for S_{min} as determined from (13) for $P = 300$ lb. per sq. in., have been plotted in Fig. 5 as curve B; the average value of S_{min} is about $\frac{7}{8}S_n$, which shows that the customary wall thickness can be reduced with advantage, especially in larger engines.

Limiting Heat-Flow Constants

The allowable value for the heat-flow H as based upon the prescribed bore temperature limits can be found by equating (9) and (11) and transposing thus:

$$H_{lim} = \frac{427}{S + 0.133} = \frac{425}{S + \frac{1}{8}} \text{(approx.)} \qquad (14)$$

The heat-flow limit is inversely proportional to an apparent wall thickness $S + \frac{1}{8}$, the constant $\frac{1}{8}$ being an equivalent wall allowance required to drive the heat from the outer wall surface into the jacket water. It may be necessary to reduce further the given value of H_{lim} in case the metal lacks uniformity or when the head parts are made materially heavier than the bore wall. Large valve openings and massive cylinder flanges localize heat-flow, and this tends to increase temperature stress and imposes additional speed restriction.

A detailed discussion of this aspect would lead too far from the present subject to warrant treatment here. The aim of the present paper is rather to determine the limiting speeds that apply to an ideal engine having the minimum of wall thickness and unencumbered with valve openings of a size sufficient to dominate speed restriction.

SURFACE FACTOR FORMULAS

In engines in which the combustion chamber is simply formed in an extended portion of the cylinder bore, the

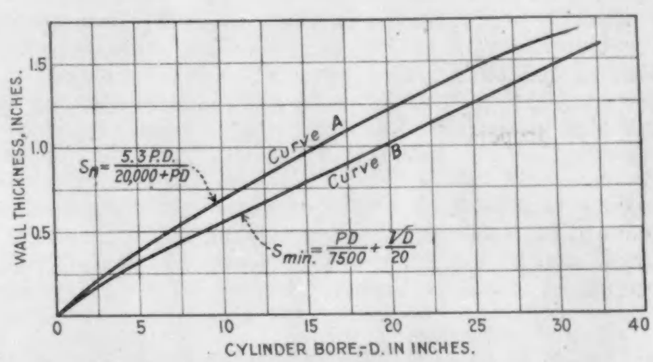


FIG. 5—NORMAL (CURVE A) AND MINIMUM (CURVE B) CYLINDER WALL THICKNESSES FOR 300 LB. PER SQ. IN. EXPLOSIVE PRESSURE

normal surface factor assumes the following numerical value when the entire piston area is taken as effective cooling surface:

$$F_n = \frac{D}{4}\left(\frac{\frac{l_o}{L} + \frac{1}{4}}{\frac{l_o}{L} + \frac{1}{4} + \frac{1}{2r}}\right) \qquad (15)$$

where $F_n = V_e/A_e$ = normal surface factor for the specified form of combustion chamber.
l_o/L = ratio of clearance volume to piston displacement, as measured in terms of the stroke L.
$r = L/D$ = stroke-bore ratio.

Surface factors applying to combustion chambers with more intricate contour can be approximated by multiplying the given value of F_n by a suitable constant. In any case, the surface factor can be expected to increase directly with the bore diameter D. The usual values for

F_n as determined for a wide range of conditions are plotted in Fig. 6. High compression oil engines possess a relatively large surface per unit of volume. For the more common low compression explosive engines, with r varying from 4/3 to 3/2 at a clearance volume of 20 to 25 per cent piston displacement, the mean value of F_n is generally found to be about $D/7.2$, as indicated in Fig. 6.

Limiting Speed Formulas for Low Compression Engines

Using the average value of $F_n = D/7.2$ as a basis for the further discussion and placing (14) equal to (1), the following relation is obtained:

$$\left(\begin{array}{c}\text{For four-stroke}\\ \text{cycle engines}\end{array}\right)\left(\frac{N}{\log_{10}N}\right)_{lim.} = \frac{1{,}600{,}000}{(S+\frac{1}{8})\left(\frac{MEP}{E}\right)^{\frac{1}{3}}D^{\frac{2}{3}}} \tag{16}$$

$$\left(\begin{array}{c}\text{For two-stroke}\\ \text{cycle engines}\end{array}\right) = \frac{1{,}000{,}000}{(S+\frac{1}{8})\left(\frac{MEP}{E}\right)^{\frac{1}{3}}D^{\frac{2}{3}}} \tag{16a}$$

The above equations permit finding the maximum allowable speed at which any given size of explosive gas or oil engine reaches the prescribed bore-temperature limit. Fig. 7 shows the relation of $N/\log N$ as plotted upon a speed basis; its numerical value can be closely approximated by the curve $1.07N^{5/6}$ as indicated.

Equation (16) can be further simplified by confining the cylinder wall to the minimum allowable thickness S_{min} as defined by (13), in which case the value of the factor $(S + \frac{1}{8})$ at 300-lb. explosive pressure can be taken as proportional to the cylinder bore, thus:

$$(S_{min} + \tfrac{1}{8}) = 0.15D^{\frac{2}{3}} \text{ (approx.)} \tag{17}$$

With this further restriction the above equations, as confined to cast-iron cylinders working with F_n = about $D/7.2$ and at an explosive pressure of about 300-lb. per sq. in., finally take the form,

$$\left(\begin{array}{c}\text{For four-stroke}\\ \text{cycle engines}\end{array}\right)\left(\frac{N}{\log_{10}N}\right)_{lim} = \frac{10{,}700{,}000}{\left(\frac{MEP}{E}\right)^{\frac{1}{3}}D^{\frac{4}{3}}} \tag{18}$$

$$\left(\begin{array}{c}\text{For two-stroke}\\ \text{cycle engines}\end{array}\right) = \frac{6{,}700{,}000}{\left(\frac{MEP}{E}\right)^{\frac{1}{3}}D^{\frac{4}{3}}} \tag{18a}$$

Corresponding values for piston speed limits are:

$$\left(\begin{array}{c}\text{For four-stroke}\\ \text{cycle engines}\end{array}\right)PS_{lim} = \frac{DrN}{6} = \frac{1{,}800{,}000\, r\log_{10}N}{\left(\frac{MEP}{E}\right)^{\frac{1}{3}}D^{\frac{1}{3}}} \tag{19}$$

$$\left(\begin{array}{c}\text{For two-stroke}\\ \text{cycle engines}\end{array}\right) = \frac{1{,}100{,}000\, r\log_{10}N}{\left(\frac{MEP}{E}\right)^{\frac{1}{3}}D^{\frac{1}{3}}} \tag{19a}$$

The curves in Fig. 8, which are derived from (18) and (19), show the manner in which heat-flow limits rotative speed in four-stroke cycle explosive engines. The restrictions imposed by heat-flow are especially marked in sizes above 10-in. bore; the allowable piston speed for large four-stroke cycle engines working with a relatively high input per cubic foot of displacement, drops to a low value as shown by curve C. No material advantage is gained by striving for too high a value of

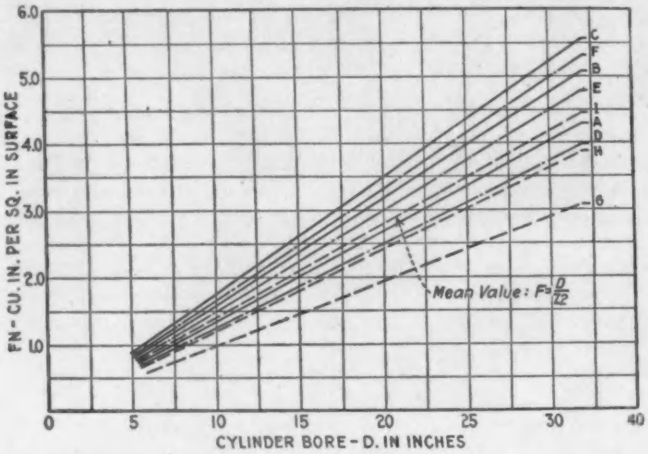


Fig. 6—Curves Showing Normal Surface Factors (F_n) for Different Cylinder Forms

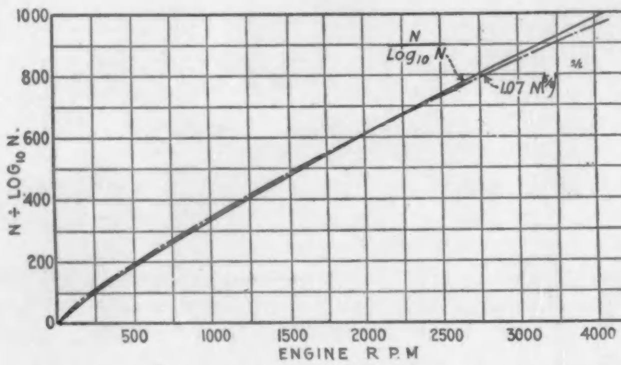


Fig. 7—Approximate Numerical Values for $N \div \log_{10}N$

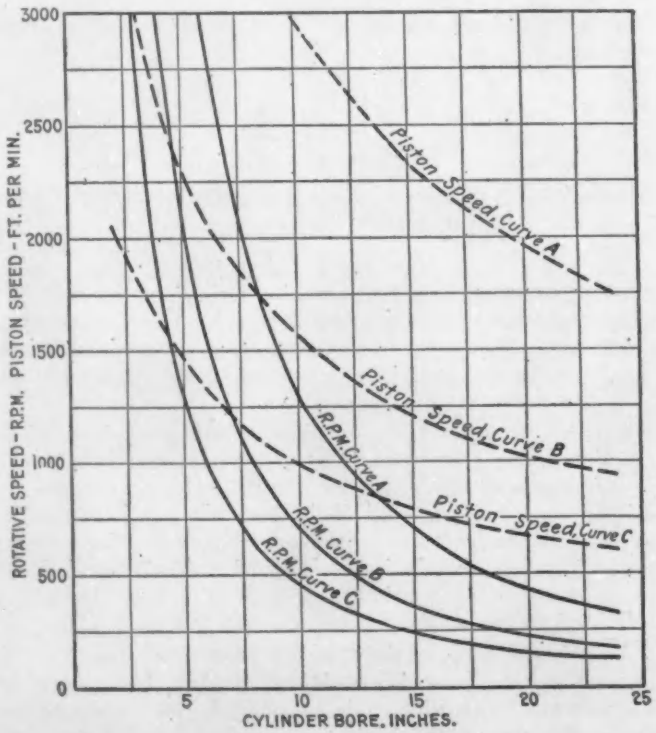


Fig. 8—Curves Showing Effect of Heat-Flow Upon Piston and Rotative Speeds of 4-Stroke Cycle Engines

MEP/E in single-cylinder high-powered engines, because the difficulties accompanying increased heat flow necessitates a reduction in rotative speed.

When practicable, this restriction can be overcome by casting the cylinder-liner and head parts of manganese bronze and like metals, since then the speed can be increased in proportion to the superior heat conductivity of such metals.

As applied to small four-stroke cycle engines, the curves in Fig. 8 show that cast-iron cylinders, when properly designed for heat-flow, should readily be able to meet the rather severe requirements of modern high-speed automobile and marine engines. This deduction is dependent upon uniform and effective cooling for all cylinder parts and upon a suitable shape for the head wall, so that it can withstand the explosive pressure without exceeding the bore wall-thickness S_{min}.

The speed constant that will prove most suitable for any particular kind of engine is naturally dependent upon the service for which it is intended. As deduced in round figures for the various kinds of four-stroke cycle gas and gasoline engines listed in Table VII, the following multiplying factors for the stipulated speed constant 10,700,000 (18) represent current practice for cast-iron cylinders:

TABLE X—MULTIPLYING FACTORS FOR SPEED-CONSTANT

Reference No.	Kind of Engine	Multiplying Factor
A, B & C	Stationary and heavy-duty marine	About ⅔ to ¾
D	High-duty marine	1 to 1¼
E	Racing engine	1½
F	Airplane, direct-connected	1
G	Airplane, gear reduction	1¼
H	Motorcycle	⅞
I	Four-cyl. automobile, moderate speed	⅞
J	Twelve-cyl. automobile, high speed	1
K	Truck and tractor engines	⅔

The safe speed limit is largely fixed by the character of service required; when continuous full-load service is demanded, it is essential to reduce the given piston speed limit PS_{min} in proportion to the given multiplying factors, so as to provide a sufficient margin of safety against excessive wear and breakdown.

While most four-stroke cycle engines operate at between 75 and 100 per cent of the so-prescribed speed limits, the corresponding average for two-stroke cycle engines is considerably lower, particularly as regards the small crankcase compression gasoline engines, which only reach about 50 per cent of the specified limit values. The low speed-efficiency of most engines of this type is to be attributed in large part to excessive bore temperature, a matter that could no doubt be considerably improved by the use of thinner cylinder walls and by giving more careful attention to heat-flow effects in the design of two-stroke cycle engines.

Two Versus Four-Stroke Cycle Engines

The various formulas show that when working with high mean effective pressures the two-stroke cycle engine is not so well adapted for fast running as is the four-stroke cycle. The two-stroke cycle can be used to best advantage when confined to long-stroke slower-running gas engines working with a relatively lower heat input per cubic foot of displacement. The lower first cost resulting from simplicity of construction and the elimination of mechanically operated valves does however give the two-stroke cycle engine a considerable commercial advantage for certain kinds of service where slow running is essential.

In the case of oil engines, the conditions become more favorable to the two-stroke cycle. The following comparison is made between the two and four-stroke cycle Diesel engines commonly used for submarine drive. Both engines are assumed to have an approximately equal rated power capacity of about 110 b.hp. per cylinder. Table XI presents the data used in arriving at a heat-flow comparison applying to these two types of single-acting Diesel engines.

TABLE XI—COMPARATIVE PROPERTIES OF DIESEL SUBMARINE ENGINES

Item	Four-Stroke Cycle	Two-Stroke Cycle
Indicated efficiency (E), per cent	40	38
MEP, lb. per sq. in	100	95
Cylinder dimensions, inches	15 by 15½	12 by 13½
Rev. per min. (N)	425	450
Surface factor F, about	1.5	1.37
Heat flow H by (1), b.t.u. per sq. in	337	450
Cylinder thickness ($Smin$), inches	1.2	1.0
Bore temperature tb by (9), deg. fahr	390	420
tb $lim.$ by (11), deg. fahr	384	395
Temp. stress ft by (7), lb. per sq. in	5220	5810
Press. stress fp by (8), lb. per sq. in	3250	3110
Total wall stress $ft+fp$, lb. per sq. in	8470	8920

The four-stroke cycle Diesel engine offers no conspicuous advantage as regards heat-flow when compared upon the basis of equal cylinder-power capacity. The two-stroke cycle engine, because of its smaller cylinder dimensions, can take care of its inherently greater heat-flow without destructive temperature effects. Furthermore, while the wall stress of the two-stroke cycle engine is shown to be greater by some 5 per cent, the conditions in the case of a high-speed four-stroke cycle engine are not really so favorable as the estimated stress relations would indicate. The large openings required for the four-stroke inlet and exhaust valves tend to weaken the cylinder-head structure and do not allow of the same uniform distribution of metal and effective cooling of the head-wall as in the case of a two-stroke cylinder when charged from below by means of piston-controlled inlet ports.

Both types of submarine engines slightly exceed the prescribed bore-temperature limits. A reduction of at least 10 per cent in the given speed would provide for greater reliability of operation, especially so since dependable service is absolutely essential for a successful submarine engine.

Jacket Loss Formulas

The full load jacket loss of any internal combustion engine, as measured in terms of heat input, is readily deduced from the foregoing equations. As based upon (2), the heat input of a four-stroke cycle engine, determined for a period of one hour, is:

$$Q = 0.185\,\frac{MEP}{E} \times \frac{N}{2} \times 0.60\,\frac{V_o}{1728} = 0.0032\,N\frac{MEP}{E}\,V_o \tag{20}$$

The jacket loss occurring during this same period is measured by the product of the effective area A_e and the heat-flow rate H, and when taken with respect to the heat input becomes

$$J = \frac{A_e\,H}{0.0032\,N\,\frac{MEP}{E}\;V_o}$$

Where J = full-load jacket-loss as measured in terms of heat input,

$V_o = \pi/4D^2L$ = piston displacement in cubic inches.

Substituting for the value of H as given in (1), the formula for jacket-loss finally takes the form:

$$\left(\begin{matrix}\text{For four-stroke}\\ \text{cycle engines}\end{matrix}\right) J = \frac{\left(\frac{l_o}{L} + \frac{1}{4}\right)\left(\frac{MEP}{E}\right)^{3/4}}{3.2\, F^{1/3} \log_{10} N} \qquad (21)$$

The relative jacket-loss for two-stroke cycle engines is found to be somewhat lower, and can be determined by substituting 3.9 in place of the constant 3.2 given in the above equation.

According to (21), the full load jacket-loss J increases directly with the temperature factor, while increased speed and a large volume content per unit surface tend to reduce the jacket loss percentage. The speed and surface factors N and F are largely predetermined by considerations other than their effect upon jacket loss, but as checked from Table IX the product $\log_{10} N \times F^{1/3}$ can be expected to lie between the limits 2¾ and 3¼, with approximately 3.0 as a fair average value.

The estimated jacket loss applying to the various kinds of engines previously analyzed for speed limits are presented in Table VIII. This estimate shows the jacket loss in the larger high-compression engines to be relatively small, that is, from 20 to 25 per cent of the heat input, while for the smaller low-compression high-speed engines the jacket loss may be about twice as large.

Constancy of Indicated Efficiency with Increased Jacket Loss

The jacket loss exerts no very marked influence upon the indicated thermal efficiency, largely because E is dependent primarily upon the ratio of expansion, as is evident from the following formula:

$$E = 1 - 1/R^{m-1} \qquad (22)$$

where $R = \dfrac{L + l_o}{l_1}$ = ratio of expansion

m = exponent of expansion line PV^m = Const.

For most explosive engines working with a reasonably clean and quick-firing charge, the average value of m is about 6/5. The value of m does not change materially with change in bore dimensions. Since the thermal efficiency of an explosive engine is dependent solely upon the difference of the initial and final temperatures of expansion, any additional jacket cooling will tend to reduce the exhaust loss by an amount practically equal to the increase of jacket loss, but without producing any material loss of indicated efficiency.

In fast running engines a loss of from 5 to 10 per cent in thermal efficiency can be expected to result from the sloping explosion line shown in Fig. 9. The relatively slow rate of combustion reduces the effective ratio of expansion in approximately the manner indicated.

Importance of Small Surface-Factors

The preceding formulas have shown the important function of the surface factor F and the advantage of providing ample cooling surface for the heat offtake. Skillful manipulation of this factor should lead to further improvement in internal combustion engine design, especially so for the larger explosive engines, in which the cooling surface is generally inadequate. In the past, excess heat-flow has been the bugbear of many of the larger high-speed engines, since it frequently leads to preignition troubles, cracking of cylinder parts and other equally unsatisfactory operative results.

For high-powered internal combustion engines to compete successfully with other forms of modern prime movers, high speed is today essential. In attempting to effect a speed increase by the use of more ample cooling surface, care must be taken to keep the combustion chamber reasonably free from pockets which are likely to trap the products of combustion and so prevent the formation of a fairly uniform and quick-firing explosive mixture throughout the working charge.

Experience with small high-speed engines shows conclusively that when considered apart from the limitation imposed by heat-flow, piston speeds as such can be increased far in excess of the limits now commonly set for the larger sizes of internal combustion engines. It is not improbable therefore that the future will see engines of large dimensions run at piston speeds that have heretofore been deemed prohibitive. To make any substantial advance along these lines will require careful attention to design details, especially so as regards heat-flow effects and lubrication.

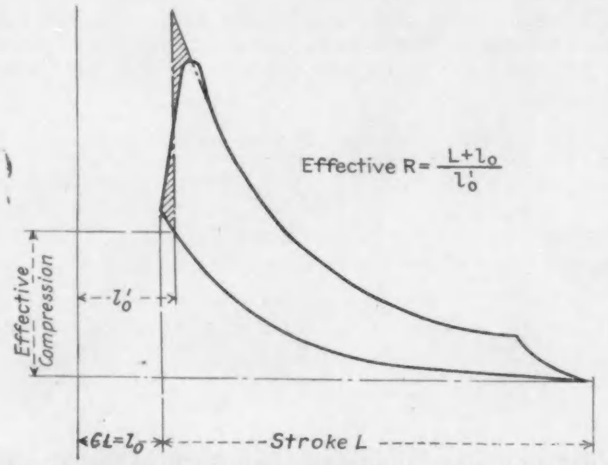


Fig. 9—Indicator Card Illustrating Effective Expansion Ratio in High-Speed Engine

Author's Conclusion

On the basis of the principles enunciated, it may be concluded that the full-load heat-flow through gas and oil engine cylinders is dependent upon three prime factors as expressed in equation (1), as follows:

(1) Temperature factor, $\left(\dfrac{MEP}{E}\right)$

(2) Speed factor, $N/\log_{10} N$.

(3) Surface factor F, effective volume per unit of cooling surface.

The designer usually strives to keep the first and second of these factors at a maximum in order to secure a correspondingly large engine output. The resulting high rate of heat-flow tends unduly to raise the temperature of the cylinder bore and head walls. The permissible rate of heat-flow is shown to be strictly limited by the resulting bore temperature, which should not exceed 400 to 450 deg. fahr., as fixed by the given method of temperature determination.

For a given rate of heat-flow, the temperature drop increases directly with increased thickness of the cylin-

der wall. Hence the maintenance of the same bore temperature in all sizes of engines necessitates a reduction in heat-flow with increased bore dimensions. Large engines are shown to reach the prescribed heat-flow limit at comparatively slow rotative speeds.

This inherent restriction can be overcome in part by making the cylinder liners of manganese bronze and like metals having a far higher thermal conductive power than is possessed by cast iron. In larger engines such innovation can be expected to lead to prohibitive first costs; hence, both from constructive as well as from commercial aspects, the author advocates the skillful manipulation of the surface factor F as the most promising method for overcoming the destructive heat-flow effects in the cylinder and head parts of large internal combustion engines.

The numerical value of the surface factor F normally changes directly with the bore dimensions, and for large engines the available cooling surface per unit of effective volume is comparatively small. On the other hand, a relatively large cooling surface per unit of volume content, as used in the case of smaller engines, serves better to diffuse the jacket loss and prevent excessive concentration of heat-flow through the cylinder wall. This results in a considerable improvement in the temperature relations and tends to eliminate preignition, excessive heating of the valves and like temperature troubles. To prevent cracking of the cylinder parts, the sum of the temperature and pressure stresses should not exceed prescribed limits.

While the proposed artificial increase in the cooling surface does increase the jacket loss, it does not materially affect the indicated efficiency. It may be expected, therefore, to improve operating conditions generally when applied to large high-speed engines.

Formulas are derived to fix the maximum allowable speed for both two and four-stroke cycle gas and oil engines as based upon heat-flow effects. For usual values of the surface factors F and the prescribed minimum cylinder wall thicknesses, the piston speed limits are shown by (19) to be directly proportional to the stroke-bore ratio and inversely proportional to the product of the temperature factor and the cube root of the bore diameter. Hence, excessive heat-flow may restrict piston speed even in the smaller high-speed engines when working with relatively large values of MEP/E.

The inverse ratio of the factor D further shows that under similar conditions of heat-flow it is not safe to run the piston speed in larger engines as fast as in smaller engines, unless compensated for by a corresponding increase in the stroke-bore ratio.

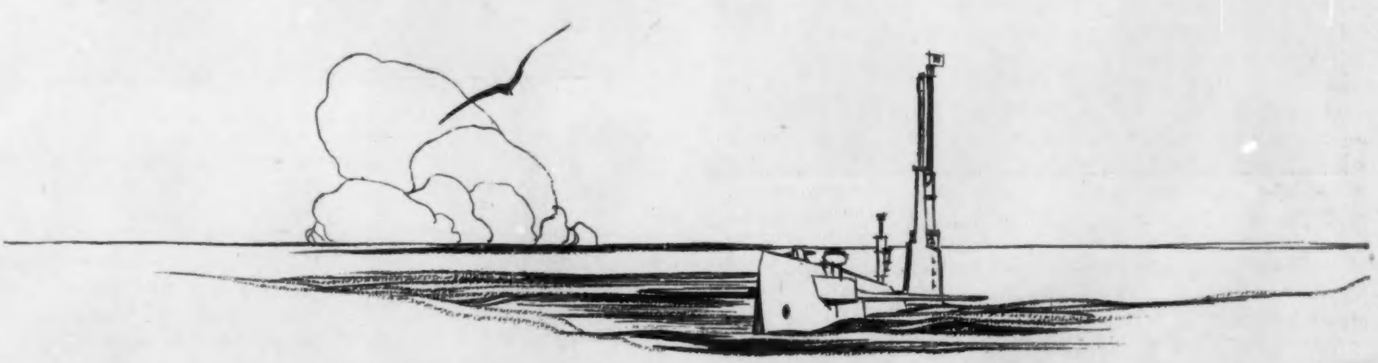
The rate of heat-flow in two-stroke cycle engines can be taken at about 1.6 that of the four-stroke cycle engine for equal numerical values of the three primary factors previously referred to. A comparison for Diesel submarine engines of equal power capacity per cylinder shows that as applied to this particular service the four-stroke cycle offers no marked advantage as viewed from the heat-flow standpoint.

The four-stroke cycle does, however, offer an important advantage when working with high values of MEP/E, such as apply in fast running marine, automobile, airplane and like gas engines. Under this condition the restriction imposed by the increased rate of heat-flow would keep the rotative speed of two-stroke cycle engines below commercial requirements.

The speed limitation imposed upon practically all kinds and sizes of internal combustion engines, both of the two and four-stroke cycle types, are shown to be identical, all being dependent primarily upon the allowable rate of heat-flow set up through the cylinder wall. In cases where well-designed engines are not speeded up to the prescribed limit such speed reduction is usually found to conform with the intended service and the general shop practice of the engine maker.

Thus the interdependence of interest between the kindred branches of internal combustion engineering becomes evident, and the need is shown of keeping in reasonably close touch with the progress made in the engine industry considered as a whole.

Finally, attention is directed to the necessity of further experimental data relating to jacket-loss tests, and it is hoped that some one of our well equipped university laboratories may see fit to undertake the extensive research investigations required to establish fully the underlying laws of heat-flow outlined in this paper.



Size, Inflation Pressure and Construction of Tires As Affecting Easy Riding

By W. S. Wolfe* (*Member of the Society*)

Pennsylvania Section Paper *Illustrated with* Photographs

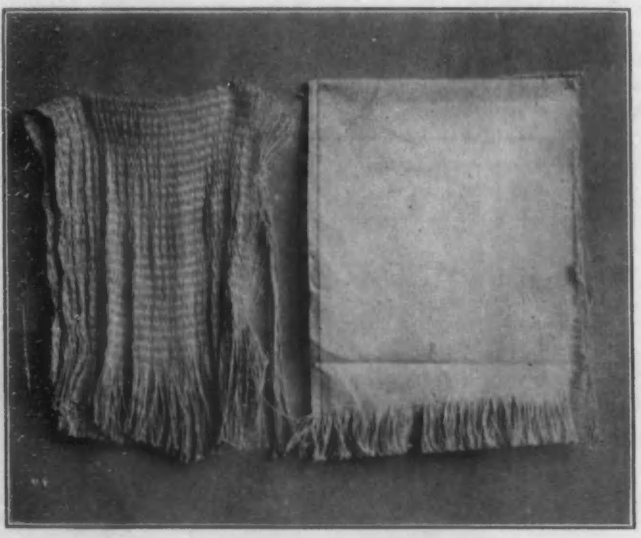
PERFECT riding qualities would be experienced on an even, smooth roadbed under which conditions the tires and springs would not be brought into play. Conditions only approximate this at best so tires and springs are constantly acting to "iron out" the irregularities of the road, to decrease the vibration which is destructive to mechanical parts, and to relieve the discomfort of the passengers.

Road conditions vary from the roughest with chuck holes, ridges and bumps to the improved highways, which are the nearest perfect.

On the former only low speed is possible and the springs and tires are constantly in action; as we approach the latter high speeds are obtainable and the tires' function is to reduce the vibration to a minimum. So springs and tires necessarily work together as the following example shows.

The operation of a car equipped with pneumatic tires but with no springs on a bumpy unimproved road would result in great discomfort to the passengers. With such a car on an improved highway the passengers would hardly feel the small unequalities of the roadbed.

A car equipped with solid tires and well-designed springs would give good performance on the bumpy road, while on an improved highway at increased speeds the vibration would be great. The nearest approach to the ideal is a car with well designed springs and adequate sized pneumatic tires.



Cord Duck
Types of Tire Fabrics

The two general and distinct types of tires on the market are solid and pneumatic. The solid tire has found its field in the motor truck, when the loads are heavy, the design substantial, and absolute dependability is necessary—all at a sacrifice of speed. Solid tires, since rubber is non-compressible, rely on this power to distort and regain original shape to absorb road shocks. The standard types of solid tires are built to obtain economy and endurance of the tire itself rather than cushioning qualities. The cushioning quality varies with the height of the tire and is gradually decreased as the tire wears down. It also depends upon the degree of softness of the compound used, but the amount of cushioning thus obtained is limited because below a certain point the life of a tire decreases rapidly with any increase in softness of the compound. With the same height of tire, added width results in an increase of the cushioning qualities.

The public has recognized the shortcomings of the standard solid tire and has had the "bugaboo" of flat pneumatic tires, so that cushion tires have come on the market with varying success. The essential features are a softer compound used in greater quantity, and designs with such unique features as air chambers, overhangs, and notches to allow greater distortion.

The pneumatic tire has already established itself on the passenger, motorcycle, bicycle and airplane. It has all but conquered on the light delivery vehicle, and the struggle for supremacy is about to start on heavy-duty trucks. The superiority is based not on lower cost per tire-mile, but on lower truck-mile operating cost; this is affected by increased speed, increased radius of operation, decreased fuel consumption, and by the decrease in upkeep and depreciation. The redesign of the truck, which is bound to come in order to reduce the weight of the carrier as compared with that of the load conveyed, will also be a factor in decreasing the operating cost.

12-Inch Cord Truck Tire on Rear of Trailer

The pneumatic tire has three types, clincher, straight-side and quick-detachable clincher. This topic† was

*Assistant Experimental Engineer, Goodyear Tire and Rubber Co.

†J. E. Hale, The Pneumatic Tire and Rim Situation, Part II, Vol. 11, S. A. E. Transactions.

discussed at some length before the June, 1916, meeting of the Society. Aside from the straight-side having a slight superiority because of increased air volume, the cushioning qualities are identical. Each type can be built in integral or two-cure construction without affecting the riding qualities.

Easy Riding Qualities

The type of construction also aids in obtaining easy riding qualities. The standardized 17¼-oz. square-woven duck used for tire fabric is being replaced in the highest grade tires by a cord that varies in size from a two-ply cable to a multiple-ply cord built up in layers. The essential feature as regards cushioning qualities is that the tire with the cord construction resists bending to a much less degree and recovers itself more readily. At the same time less internal heat is generated and the power consumption is decreased. The fundamental principle is that a cord tire, because of its construction, can carry a given load with less air pressure and without fatigue or injury than can a fabric tire. A great gain in riding qualities results therefore from the use of cord tires.

A far more important point to the easy riding and life of the tire is the tire size and inflation pressure. The proper tire to carry a given load is important to both car owner and manufacturer. As soon as the owner finds his tire service is poor because of overloading he puts more air in his tires to carry the load and thereby loses the qualities which give easy riding.

Inflation and Load Table for Pneumatic Tires

Inflation Pressure	Section Diameter of Tires, Inches											
	3	3½	4	4½	5	5½	6	7	8	9	10	12
45	375											
50	415	520										
55	460	570										
60	*500*	620	750									
65		675	815	955								
70		*725*	875	1030								
75			940	1100	1280							
80			*1000*	1175	1365	1550						
85				*1250*	1450	1640	1860					
90					1535	1740	1970	2450				
95					*1620*	1835	2080	2585				
100						*1930*	2190	2720	3280			
110							*2410*	2990	3605	4250		
120								*3260*	3935	4630	5360	
130									*4260*	5020	5810	8070
140										*5400*	6260	8360
160											*6710*	8940
170												*9800*
180												....

Maximum inflations are given in italics.

The inflation schedule, given in a paper* delivered at the June, 1915, meeting of the Society, shows the amount of load and inflation under which a given size of tire works satisfactorily. For ideal performance the tire should be deflected from 10 to 12 per cent of the sectional height. This gives the best combination of durability and riding qualities.

Let us take an example of good practice. If a 1000-lb. load is to be carried, a 4-in. tire at 80-lb. pressure would give reasonable satisfaction, but would be hard and rebound at uneven places in the road. The owner, if not satisfied with the riding qualities, might decrease the pressure and gain easy riding at the sacrifice of durability. The life of the tire is thus impaired. The most satisfactory answer is to use a 35 by 4½-in. tire and to decrease the pressure to 67 lb. This gives the proper 10 to 12 per cent. deflection, and the tire is good for long service. The riding qualities have been wonderfully increased, because the tire at the reduced air pressure is flexible and adjusts itself to the unevenness of the road, thus transmitting none of the vibrations.

It is to the advantage of car manufacturers to equip as nearly as possible their cars with tires conforming to the sizes given in the table, or the car will enjoy the reputation of hard riding or that of a tire hog as the case may be. Overloading on original equipment has been practised to a considerable extent, but manufacturers are more and more beginning to appreciate the evil results.

Analysis of Causes of Pneumatic Tire Troubles

1. Unsatisfactory tread wear.	caused by	Wheels out ot alignment Poor road surface conditions Too much power Improper use of brakes Disintegration from oil Skidding Under inflation Cutting of tread rubber by sharp stones
2. Separation between the plies of fabric; and separation of the tread from the carcass	caused by	Riding flat Riding under inflated Punishment on rough roads Riding on car tracks Water soaked Overloading Heating from speeding Started by cuts
3. Fabric breaks; and carcass blow-outs	caused by	Overload Under-inflation Stone bruise Flexing of the carcass fabric (after long service)
4. Bead troubles	caused by	Under-inflation Overloading Bent rims Injured in applying Riding flat
5. Tube troubles	caused by	Leaky valves Pinched tubes Punctures Riding flat Heating from speeding

It is unfair to the car owner if the manufacturer uses an over-size tire as original equipment and does not leave any alternative in case the owner wishes to use larger tires without changing the rim and wheel equipment.

The inflation schedule, given in a paper* delivered at easy riding into the tires and along with it he has put in more life and durability. He has made the tire oversize to such an extent that the actual section is from ¼ to ⅜ in. greater than the nominal. He gains the effect of an oversize and thus allows the use of lower air pressures, the recommended decrease being 10 per cent. To this oversize feature a great deal of the easy riding and endurance of the cord tire can be attributed.

The tire's overall diameter affects the riding qualities only slightly, but it is noticeable that as the roads improve the diameter decreases. This is shown by the fact that English and French tires are made in small diameters owing to the better highways.

Pneumatic Tire Service
Five Major Troubles vs. The Operating Conditions

1. Tread rubber wear 2. Separation between plies; and separation of tread from carcass. 3. Fabric breaks; and blow-outs. 4. Bead troubles. 5. Tube troubles.	each considered against	A. The load carried. B. The inflation pressure. C. The speed. D. The spring suspension. E. The power of the engine. F. The condition of the road surfaces. G. The nature of the country. H. The weather. I. The temperament of the driver.

Heavy Trucks on Air

The following is an extract from an article by P. W. Litchfield on History's Lesson to the Motor Truck, which appeared in the Nov. 10, 1917, issue of the *Scientific American*, and states clearly the reason for mounting heavy loads on air.

*P. W. Litchfield, Size and Inflation of Pneumatic Tires, Part II, Vol. 10, S. A. E Transactions.

"With steel tires the bicycle made but slow progress; the adoption of the solid rubber tire gave it increased public usage, but the pneumatic tire made it a big industry. The use of the solid tire on carriages increased the comfort of riding, but the pneumatic tire allowed the carriage to go so fast with comfort and safety that the horse was outgrown and became too slow, the result being the substitution of the engine.

"The automobile was made possible by the pneumatic tire. The internal combustion engine is a delicate mechanism. It has to be geared to the wheels in some form, hence the necessity of a perfect road, or of absorbing the shocks before they reach the wheels. The pneumatic tire performs this function most efficiently. The pneumatic-tired automobile replaced the horse-drawn carriage, because it saved time, went farther and faster. It increased the amount of travel and increased the distance traveled. Statistics show that now, after the few years of their existence, automobiles are covering as many passenger miles as the railroads; not that the railroads have suffered any great loss of business, but that the increase has been created and absorbed largely by the automobile.

"Following the passenger car came the light delivery truck, this replacing the horse-drawn truck, largely on pneumatic tires. Then we find the motor truck used in larger and heavier fields, still making an attempt to replace only the horse, and equipped with solid rubber tires, which had been practically abandoned on every other form of motor vehicle almost immediately after their adoption. Evidently the tire maker had not kept pace with the development of the truck or the truck builder was making a mistake. Up to now, the former is probably the case.

"It has long been known to the tire maker that compressed air with a durable container is the most efficient cushion and traction shoe for the wheels of an automobile. Also, that the load and cushioning quality depend merely on the volume and pressure of the air. If the product of volume and pressure is great enough, there is little fatigue and wear to a properly designed tire casing. The manufacturer of practical commercial pneumatic tires jumped from the 1½-in. bicycle tire to the 4½-in. automobile tire in a year or two and the latter has been the maximum size up to the present time. The resistance of close-woven fabric to taking the form of a doughnut, its inability to stand the flexing and traction of greater loads, and the greater stretching and crimping given it in the larger sizes, seemed to establish the 4½-in. size as the limit.

Future Tire Sizes

"The progress of tire design during the last two years has shown that this limit no longer stands if, instead of woven fabric, laminated cords without cross weave are used. These cords take the strains without undue fatigue and we now see our way clear to pass from 4½-in. cross-section to 12-in. cross-section as easily as we went from 1½-in. to 4½-in. It is only a question of study to perfect the large pneumatics so that the truck can repeat the remarkable growth of the passenger car. Pneumatic tires up to 9-in. cross-section are now in successful commercial use on trucks and passenger buses. The speed of and the distance traveled by these vehicles have been increased and the upkeep costs reduced. The tire cost per mile may be higher than with solid tires, but this same is also true of passenger cars. A solid-tired touring car would have a tire mile cost of less than half that of one with pneumatics, but all other costs—fuel, upkeep and depreciation—would be higher.

"The first trucks designed for solid tires were lighter than those in use to-day, but the vibration caused so much breaking of parts that they have been strengthened and reinforced repeatedly. This can all be saved by using pneumatics, permitting lighter chassis and bodies to carry heavier loads. Also the traction of large single pneumatics is much greater than that of solids so that the trucks can be operated in sand, mud and snow, where the solid-tired trucks would be stalled. The gasoline and oil consumption is much less when pneumatic tires are used.

"The motor truck so far has only attempted to replace the horse in hauling merchandise because the solid tire has so limited its speed that it could not compete with any form of transportation requiring long hauls at higher speeds. When it can accomplish this, it so enlarges its field that it becomes a real competitor of the railroads."

The Discussion

A MEMBER:—Assuming that we have two tires of the same diameter and at the same pressure, one of which is of cord and the other of fabric, is the difference in the riding quality appreciable?

WILLIAM S. WOLFE:—The difference in the riding quality would not be great. The main difference would be in the ability of the tire to bend. A tire of the cord construction will return to its shape much more easily than will a fabric tire. Before it was realized that it was necessary to tell the customers about it, a number of cord tires were put on the market with the same inflation pressure marked on the side that the fabric tires had. A man would substitute at the same pressure cord tires for fabric tires, which would then bounce over the road so much that he would become disgusted with them. On one particular car the rear end jumped sideways, and the owner was disgusted with the cord tires. He was told to decrease the inflation pressure 10 lb., and was immediately satisfied with the results.

A. K. BRUMBAUGH:—It is practical to put on a pneumatic tire that will stand a pressure of 160 lb., but we have nothing with which to pump it up.

WILLIAM S. WOLFE:—An engine pump is used for large tires on trucks that go any distance from home. We have a four-cylinder tire pump, water-cooled, which has given us more or less satisfaction, although it is not perfect by any means. It will pump to 160-lb. pressure. We have never used over 140 lb.

ACTING CHAIRMAN H. R. COBLEIGH:—As far as easy riding is concerned it seems that we do not want solid tires; that the pneumatic tires should be of the cord construction rather than the fabric; and that oversize tires should be applied if the car was not originally equipped with them, so that we would not have to use the maximum pressure recommended by the tire companies.

The point has been made that the larger diameter tire will not sink into the road, but will bridge the worst faults in the road. Of course, on a smooth road we would not be worried about easy riding, but on a cobblestone or a Belgian block paved street will the 36-in. have a great advantage over the 32-in. wheel?

WILLIAM S. WOLFE:—When the difference is as small as an inch or two the effect is not noticeable. The diameter of the tire must be determined by the car manufacturer rather than by the tire manufacturer, according to the height the former wants the car off the ground.

I believe the larger diameter tires were used in order to bridge over obstructions in the middle of the road, so that the clearance would be increased, rather than with any thought of easy riding. Strictly speaking, the larger wheel is slightly better from the standpoint of easy riding.

Location of Center of Gravity

ACTING CHAIRMAN COBLEIGH:—Would the raising of the center of gravity of the car make or mar easy riding, ignoring now the impacts or the ruts?

F. E. DAYTON:—I think it is agreed in Europe that it is important to reduce the center of weight. I do not believe cost was a consideration. For instance, over there they would not leave off striping a car to save 50 cents, and they would here. I think in two or three years no cars will be built with tires larger than 32 by $4\frac{1}{2}$ in.

There was a time when a man would not buy an automobile unless it had an 11-in. clearance. The tire manufacturers are agreed that 32 by $4\frac{1}{2}$ in. will ultimately be the big size, just as trucks ultimately will be carried on cord tires. An investigation by our company has kept us from going into the solid tire business because we believe that all trucks up to 3 tons' capacity will be carried on cord tires.

J. C. WEBER:—What difficulties were experienced in using the 60-deg. thread fabric over the 45-deg., and was there any improvement in the riding qualities of the car with the former?

WILLIAM S. WOLFE:—One British company made two types of cord tires, one for electric vehicles and one for gas cars. I think the gain was not sufficient to warrant making two types of tires, and I understand that the difference in wear was something like 20 per cent. The separation and the fabric troubles were increased as much as 20 per cent.

J. C. WEBER:—Was this test made on a two-ply cable cord?

WILLIAM S. WOLFE:—Both companies have made these tests and each construction was used. I never heard anyone from the British company discuss why the manufacture of the 60-deg. angle tire was discontinued, but it was, I am sure, because the latter was not so satisfactory, although a little bit livelier than the 45-deg. angle tire.

Result of Resiliometer Tests

Many tests were made on a resiliometer, and it was possible to compare the easy riding qualities of the 60-deg. angle tire with the 45-deg. angle tire. The power consumption was what was considered then so that the electric car would travel as far as possible. The mileage was greater with the 45-deg. tire.

A MEMBER:—Reference was made to the tendency of the cord tire to bounce badly until the pressure was reduced below that ordinarily used with a fabric tire. Does that mean that under similar conditions the cord tire will not hold the road as well as the fabric tire will?

WILLIAM S. WOLFE:—I believe that the cord tire bounces more.

THE MEMBER:—The wear of the tread then would be more rapid owing to spinning of the wheels when off the ground.

WILLIAM S. WOLFE:—We have found as a result of road tests on a number of tires of various sizes, that the apparent tread wear on a cord tire was anywhere from 5 to 15 per cent less than on a fabric tire.

A MEMBER:—What is the principle of a resiliometer? Is it an instrument for recording the number of bounces before the tire comes to rest?

WILLIAM S. WOLFE:—No, it is really a machine for measuring power consumption. The tire was mounted and driven from a variable-speed electric motor and the power transmitted through the tire, and a dynamometer read on the other end.

A MEMBER:—My object in asking the question was to find out whether any sluggish action was an advantage or disadvantage. The fabric tire does recover a little more slowly than the cord tire, and has a tendency to hold the road better under pressure conditions.

WILLIAM S. WOLFE:—It looks as if it might be an advantage, but it is gained to a greater extent by lowering the pressure in the cord tires than it is in running the fabric tire at lower pressures, as in one case the mileage is good and in the other poor.

A MEMBER:—I have always believed that the extremely light weight tire, as the Palmer tire, in the bicycle days, was better than the others because it was not sluggish.

ACTING CHAIRMAN COBLEIGH:—We are apparently to conclude that if the cord tire has the same cross-section diameter and the same inflation pressure it would not ride more easily than the fabric tire.

A MEMBER:—We made a bounce test with a 36 by $4\frac{1}{2}$-in. fabric and cord tires, and found that the cord tire bounced from 33 to 40 per cent higher than the fabric.

WILLIAM S. WOLFE:—There is a limit beyond which we cannot go. If the tires are pumped so hard that there is too much rebound and the car is bounced off the ground, the riding is harder.

Importance of Inflation Pressure

A MEMBER:—While we have to publish inflation tables, all that we require at all times is not any definite number of pounds pressure, but that the tire be well rounded out.

If the car is fitted with tires of ample capacity, not as much air is needed in the same size of tire. It does not necessarily follow that because one man has put in 85 lb. pressure that the other man must.

ACTING CHAIRMAN COBLEIGH:—The tire construction is not so important to easy riding as its inflation pressure.

WILLIAM S. WOLFE:—That is what I should say. The important thing is the inflation pressure and the size.

JOHN W. WATSON:—When dropping the two wheels so that they hit with the same force, and one of them bounces higher than the other, is not that an indication that the one which bounces higher has been more completely compressed by that force, and can therefore be said to have absorbed more of the shock of the force? If the above is true, it seems to me that the cord tire, the one which bounced higher, would prove to be the better of the two tire constructions as a means for absorbing road shocks.

WILLIAM S. WOLFE:—Suppose it bounces the car more afterward?

JOHN W. WATSON:—It sems to me that inasmuch as the recoil of any tire is such a negligible factor, it is more important to provide a tire which is best able to absorb shocks regardless of whether this ability causes the tire to produce a slightly greater recoil action. If, upon encountering a stone, the tire is able to compress so that it is wrapped completely around the stone, the tendency to bounce the wheel will be less than if the stone is only partially embedded into the tire.

ACTING CHAIRMAN COBLEIGH:—The height to which the tires bounce is merely an indication of their elasticity.

WILLIAM S. WOLFE:—When a tire hits the ground, the

air pressure resists the change, and the tire itself resists the change; the air pressure in the cord tire has to take more of the resistance than it does in the fabric tire.

This is true because the cord tire does not resist change as much as the fabric tire. Therefore, if the inflation pressure was low enough not to cause bouncing off the road the deflection would be greater and the riding qualities easier than in the fabric type.

A MEMBER:—Then with a fabric tire the mileage per gallon of gasoline will be less under the same pressure, and that would be the main reason for using the cord tires.

WILLIAM S. WOLFE:—That is another reason for using cord tires beside the easy riding.

ACTING CHAIRMAN COBLEIGH:—What effect does the use of wood or wire wheels have on easy riding? A number of years ago tests were made by a taxicab company, in which a large number of identical cars were used, some equipped with wood wheels and others with wire. A much higher mileage was obtained with the wire wheels. Does it follow that there is any gain in easy riding, and what advantage would the wire wheels have so far as the tire is concerned?

A MEMBER:—With wire wheels the load is from tangent spokes rather than on a peg.

ACTING CHAIRMAN COBLEIGH:—Is that better for the tire?

THE MEMBER:—The most recent tests have proved that it is not.

Effect of Temperature

ACTING CHAIRMAN COBLEIGH:—Does the temperature make much difference in the pressure?

WILLIAM S. WOLFE:—That is a much abused subject. An increase of temperature of about 25 deg., which is about as much as would be gotten under ordinary conditions, results in an increase of about $4\frac{1}{2}$ lb. in pressure, and does not make a great deal of difference in the riding quality of the tire. Of course, as the pressure increases the tire rides a little harder, but a man decreases the pressure in warm weather because his tires are heating up; the temperature is increased a small part of the day and a small part of the time. The tires cool off rapidly enough so that most of the time he is running with $4\frac{1}{2}$ lb. less pressure than he should have.

ACTING CHAIRMAN COBLEIGH:—This increase is due to the atmosphere?

WILLIAM S. WOLFE:—No, it includes the temperature increase due to internal friction. When De Palma drove the six-hour race in New York, the increase in pressure in the tires was a maximum of $3\frac{1}{2}$ lb. He averaged 102 m.p.h. for the six hours. It was the first time that straight-side tires were used without any locks; just an ordinary pair of straight side tires and ordinary tubes were used.

C. R. COLLINS:—I understand that the tires and rims were especially constructed.

WILLIAM S. WOLFE:—The rims were built for him, but they were selected from stock and laced up in the ordinary way, when they were first made, in order to be sure a cotter pin was inserted. He has run around time and again without cotter pins.

A MEMBER:—Is anybody building tires with a combination of square woven close fabric and cord, and what would be the advantage, if any, on that beside cost?

WILLIAM S. WOLFE:—I have not seen any on the market and think nothing would be gained.

JOHN W. WATSON:—What is the disadvantage of a large section tire?

WILLIAM S. WOLFE:—Beyond a certain point, the amount of air inside of the tire governs the amount of surface that hits the ground. If the air pressure is 90 lb. per square inch there is not as much surface on the ground as if it is 45 lb.

A MEMBER:—Could not the tread be so constructed as to govern the area on the ground? A billiard ball would be the ideal for speed, but it would not have the traction.

WILLIAM S. WOLFE:—The air is what supports the tire. The treads could be made with peaks, but then the construction of the tire is made difficult. If too much rubber is put in the middle, so that that is the only part touching, it would wear out quickly. If the tire is built flat across, the load is equally distributed and the load near the side is too great.

Minimum Air Pressures

ACTING CHAIRMAN COBLEIGH:—It seems that the lower the pressure carried the easier the riding. Is there any danger of going too far in that way? Suppose we put on a sufficiently over-sized tire so that, according to the load on the wheel, we could carry as low as 20-lb. air pressure?

WILLIAM S. WOLFE:—That would be governed by the fact that the rim would be hit. When that condition is obtained the pressure is too low.

ACTING CHAIRMAN COBLEIGH:—What would be the minimum air pressure?

WILLIAM S. WOLFE:—Roughly speaking, I should say 30 lb. would be low.

ACTING CHAIRMAN COBLEIGH:—Nothing would be gained, practically, by going lower than 40 lb.

WILLIAM S. WOLFE:—In many cases 35 lb. is used when the owners do not care how much the tires cost. They do that to get the easy riding qualities. On a roadster with 34 by 4-in. tires I used between 25 and 35 lb. air pressure. The car rode fine, but I got lower mileage than would satisfy the average car owner.

ACTING CHAIRMAN COBLEIGH:—For easy riding we cannot consider anything, it seems, but the pneumatic tire; that is, we cannot approximate the easy riding of the pneumatic tire with a solid tire. For easy riding alone, the most important thing is the inflation pressure, which to a certain limit should be as low as possible. Then we should make the tire of proper diameter to carry the load; beyond that the construction of the tire, whether fabric or cord, is relatively negligible. This applies just for easy riding; leaving out the question of wear entirely, although of course everybody will consider that.

JOHN W. WATSON:—From what we have heard it seems to have been proved that while the cost of pneumatic tires on a truck is far in excess of the cost of solid tires, this excess is hardly an item to be considered when compared to the lessened wear and tear on the vehicle and the saving effected. Is it not possible that larger pneumatics on passenger cars might result in a similar gain?

WILLIAM S. WOLFE:—I think that with large tires their extra cost more than makes up for any saving in upkeep.

Automotive Industrial Efficiency

By Geo. C. McMullen* (*Member of the Society*)

Detroit Section Paper

THE Planning and Mechanical Efficiency Division of the Industrial Research Committee was appointed to discuss a branch of the Automotive Industry not generally considered in engineering meetings, but one closely allied with the engineering fraternity that has kept pace with each advance in the design of vehicles that really are little less than marvelous when we make comparison with the American car of fifteen years ago. No other industry has gone ahead with such leaps and bounds, and it has been accomplished only through the combined efforts of the engineer and the shop.

It is of the Shop, or Manufacturing Department, with which our Committee will deal, and we will present some of the problems met with in the scheduling, shop equipping and producing of cars or trucks, after the design has received the approval of the engineer.

We want to thank the companies which assisted us in preparing this paper, particularly the Ford, Packard, Hudson, Hupp, Chalmers and Timken Companies.

The automobile and motor truck as seen on our streets today have become so commonplace that we are apt to lose sight of the fact that back of each car or truck stands an organization established to produce that vehicle, first in the brain of the engineer through the demand of the buying public, then in the design as laid out on paper, later in the raw material that is machined into the finished details to be finally assembled, tested and turned over to the public through the sales department.

Industrial Organization

The make-up of this organization varies so that we will show a general chart, Fig. 1, giving the branches and departments. It is fundamentally necessary that a successful plant must be so organized that each department will be responsible to its head and he in turn to someone higher up and at the same time will cooperate with all other departments.

The General Manager is here assumed to be the active head of the organization and from him all the lines of authority radiate. Under him the departments of equal authority are the Secretary and Treasurer, Engineering, Purchasing, Sales and Manufacturing. The duties of each of these departments are shown on the chart.

The manufacturing is under the control of the Works Manager as shown and the General Superintendent reports direct to him. The Planning, Foundry, Forge and Machine Shop Superintendents, Maintenance Engineer and Chief Inspector all have equal authority, reporting to the General Superintendent.

The Works Manager is responsible not only for the building and shipping of the finished product, but also, through the Planning Department, for everything that goes into the finished car from the time the order is placed by the Purchasing Department until the car is shipped.

An analysis of the future market by the Sales Department will give a rough idea as to the quantity of cars the company should plan on for the season's production, and from this forecast the General Manager can settle on the building schedule.

The number of roadsters, five-passenger touring cars, etc., must be definitely settled for each production period in order to allow the Purchasing Department to place orders for the proper quantities of the parts required. Unless these quantities are delivered at the proper time and in proper amounts, the work in process inventory will do all sorts of things, and finally a large overstock of some parts and none of what is required will play havoc with any building schedule and also tie up several million dollars' worth of material that cannot be moved.

Work of Planning Department

To avoid this, to give the Service Department the quantities of parts for a reasonable period, and to build all of the last few hundred cars, the Planning Department is organized, with duties as shown on the chart, not alone to see that the proper piecework price is set on the work, or that the production each day is up to schedule, but also to control incoming material from all sources and to allow only enough of these parts to be received to maintain the building schedule.

To incorporate this important feature in the work of the Planning Department it is necessary either to take the specifications off the Purchase Order and relieve the Purchasing Department of the follow-up work as well, or to let the Purchasing Department have charge of the planning. This would hold true whether the Purchasing Department was under the General Manager or the Works Manager, as is sometimes the case.

The easier way to start a material control would be to take up this work at the end of the production period, when purchase orders are being placed for a new run or a new model. It is, however, feasible to start it at any period of production and gradually work up to the goal desired.

We will take a new model that is to be built and put on the market as the example, and assume the Engineering Department has satisfied itself as to the car and has prepared all the drawings and parts lists required by the Purchasing Department to buy the material; that the stock rooms are ready, so that the different parts will be properly inspected, tagged, and disposed of when received; also that the necessary drawings are furnished the factory so that it can make and assemble the parts as required to build the finished product.

The management must decide how many cars it proposes to build for the season's production, and for the first production period (usually three months) how many of each model. This building schedule is turned over to the Purchasing Department with authority to place the necessary purchase orders. The purchase order does not specify when the deliveries are to be made, but simply states the total quantity required and that the Material Department will give notice as to the shipping schedule.

Each month the Planning Department prepares a financial material budget, and gives to the General Manager, two weeks in advance, the approximate amount of money that will be required to finance the incoming

*Prepared by the Planning and Mechanical Efficiency Division, consisting of Geo. C. McMullen, assistant plant manager, Waterloo Avenue Plant, Timken Detroit Axle Company; C. A. Marston, Hupp Motor Car Corporation, and C. W. Avery, Ford Motor Company.

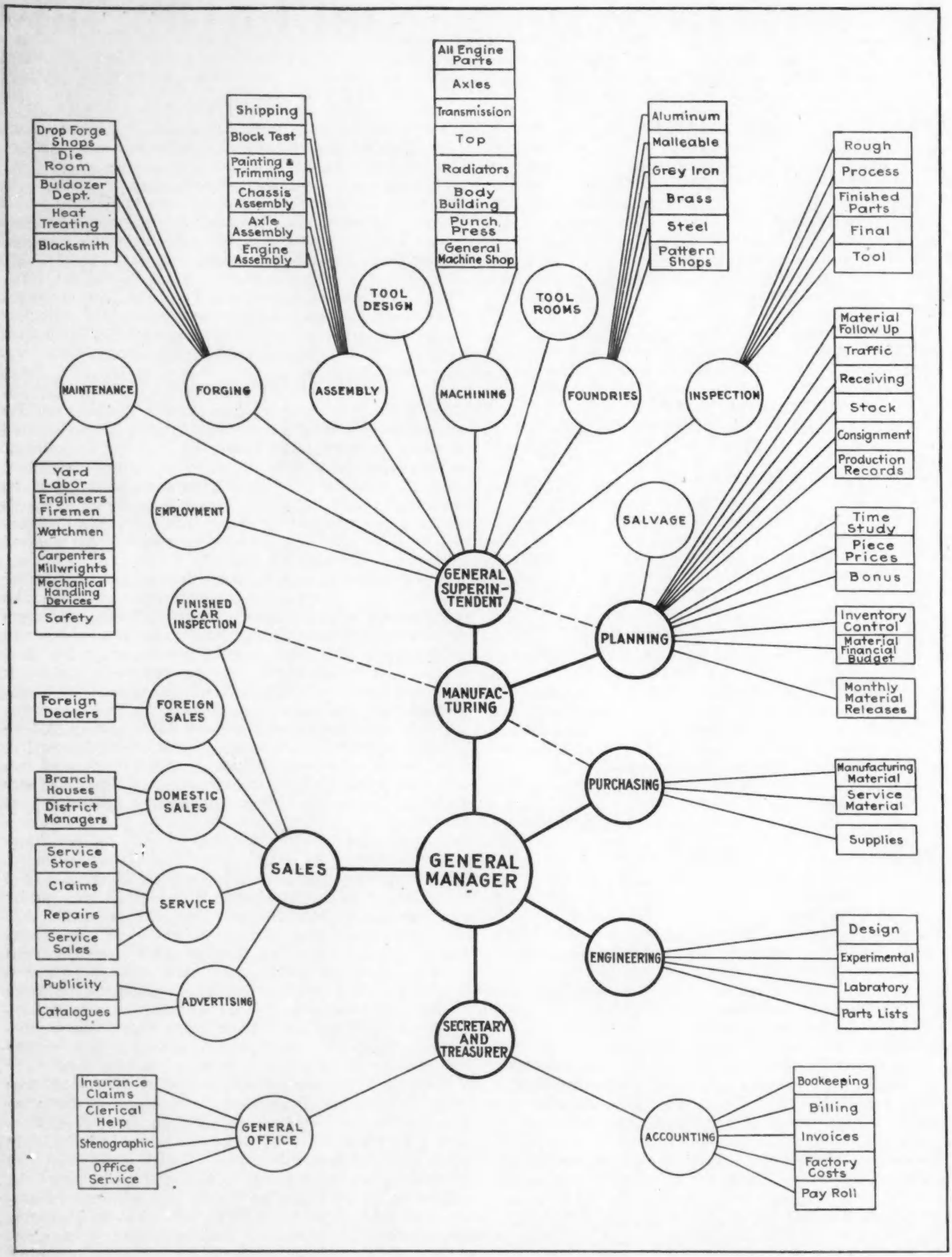


Fig. 1—Chart Showing Make-Up of Various Branches and Departments of a Manufacturing Organization

material up to and including the first of the following month. This is one of the reasons why the Planning Department should control the receipts of material.

Supplies for Work in Process

After the purchase orders have been issued the Planning Record Control Sheet is made out, and after each part has been recorded a list of releases on the purchase orders is taken off. In addition to the actual building schedule a work in process supply must be provided, which in some cases is very large. This is the safety valve, and must be carefully maintained. It is this work in process that allows the factory to continue to build cars when traffic conditions hold up shipments of material. The requirements for each part must be carefully analyzed to insure an even flow of production.

The first release on the purchase order will take care of this work in process and also include the production requirements for the first three months. Immediately this release list is prepared, letters are sent to the different sources of supply, giving them authority to make the specified shipments.

When possible, it is better to make each month's shipments in one, provided the material is not too bulky. This applies more to freight shipments than "in town" shipments, but only the quantities specified for that month should be received, except by special acknowledgment. The reason for this is obvious, for if large quantities were received, the financial budget, which is prepared in advance, would soon be incorrect, and a badly unbalanced inventory would result, tying up a large amount of money on a few parts, and requiring additional large expenditures to pay for the rest of the parts necessary to complete the unit.

A successful company would not spend all its money experimenting on a model and then have nothing left to run on when the design was perfected; neither is it possible for a large manufacturing company to be successful if all of its departments are not evenly balanced. A factory might be 100 per cent efficient so far as machines, tools, and methods were concerned, but lose money because the material was not in the plant at the proper time.

It is, however, quite possible to organize the Material Planning Department so as to keep records properly, control the easy incoming material, push hard the difficult parts, and balance production to a remarkable extent.

Checking Rough Parts

Of vital importance, before the material reaches the machine floor, is to have it in a condition to allow of ready machining. This can best be accomplished by a careful check on the patterns and dies from which castings and forgings are to be made, and also by the inspection of samples of all material that is to be purchased outside complete. A special department, usually under Inspection, handles this work. Close comparisons with the blueprints are made and a report sent to the maker showing just how the sample may vary from specifications. A record is kept of all reports, together with marked blueprints and samples, for reference when the next samples come in.

This department also follows up all engineering changes that affect patterns and dies, passing on samples and reporting to the Purchasing Department where changes have not been made. Ofttimes letters and blueprints do not bring the desired results, in which case a man from this department should visit and see personally that the firm in question understands the requirements, and, if necessary, stay until the changes are made. Trips of this sort, when made by the right person, will tend toward a much better understanding between the company and the source of supply and save a great deal of needless delay.

RECEIVING METHODS

With the order placed, samples approved, and material coming in, one of the big problems to be considered is that of receiving the material properly, making the count, keeping receiving records, general inspection and proper handling and storing. The receiving reports sent through to the Planning and Accounting Departments must cover the actual count and weight of material, and whether passed or rejected by the Inspection Department.

Various methods are in use for handling material as it comes in, such as unloading from cars direct to stock, to an inspection room, or in the case of the larger parts direct to the machining floors. Traveling cranes with magnetic hoists, power trucks and conveyors are some of the methods of rapidly unloading and handling stock from cars. One firm has a long receiving dock, built on a level with the car floor; there are ports in the floor through which the material can be distributed to the bins below by means of chutes. In the case of large castings and forgings it is general practice to run the cars to an unloading platform near the room where the parts are to be machined, thus avoiding unnecessary handling.

Some form of inspection is necessary on all material coming in, to determine defects not due to errors in the original samples, such as molding defects and warpage in castings, cold shuts in forgings, and those caused by the natural wear of dies. Hardly two companies handle this inspection alike. Some inspect each part, others a percentage of the small parts and all of the larger ones, while others send the parts to the assembly floor to be inspected as used, or depend on the operator throwing out the parts not fit to use. The most satisfactory results are obtained, however, by a fairly close check on all parts before they are sent to the machine floor or to stock, for the time to catch the defects is when the material is received, so that sources of supply can be notified, and also to avoid delay and confusion in the Machine Department.

Choice of Equipment

The first consideration of the factory organization after receiving the yearly schedule is to determine the machine equipment necessary and the proper machine floor layout to produce daily the parts required by the Assembly Department to make its schedule. It is safe to say that one of the real factors in the success of quantity production today lies in the proper selection of machine tools and in their arrangement, or floor layout. Some of the best trained minds in the industry are at work on these two problems only, and the item of expense is not considered when the final results can be obtained.

Machines are designed and built for the single purpose of performing as many separate operations as possible at one set-up and to work continuously with little attention, except that needed to place and remove work, thus allowing the operator to handle several machines. For example, the large mills, with horizontal and vertical facing heads, that rough and finish face the top and ends of crankcases, or the ends and sides of cylinder blocks; straddle-mill the forked ends of front axle centers and at the same time face the spring seats; boring mills with turret heads capable of handling several operations; or

the heavy duty drills with multiple spindles, boring cylinder blocks at one set-up.

The machine equipment required is dependent on the schedule of production; the kind and capacity of machines must be decided upon before the actual number necessary can be determined. In deciding on the kind of machines, each part to be machined must be considered carefully, and a machine selected that will perform the most operations with the required accuracy at the lowest maintenance cost. Precision, durability and performance are the three qualifications to be desired. After the kind of machines to perform all of the operations on a detail part is decided, the actual number to produce the daily schedule is readily determined; an over-schedule should be figured on to allow for scrap material and unavoidable delays.

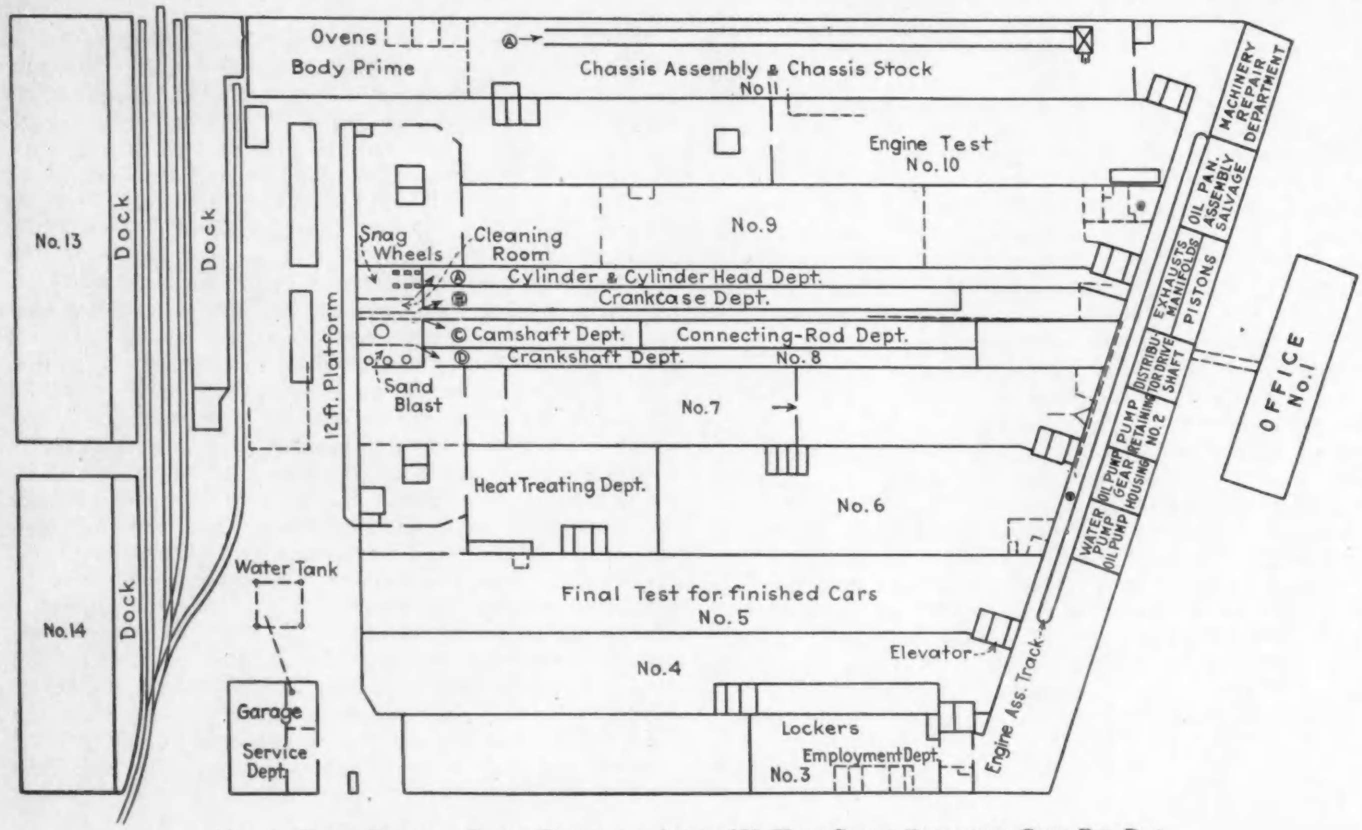


Fig. 2—Floor Plan of Plant Producing About 150 High-Grade Passenger Cars Per Day

Grouping of Machines

Experience has shown that the grouping of machines on the floor in order to perform the sequence of operations results in maximum production with minimum cost. This method is in general use today in those plants that are considered large producers. Some of the advantages of this method follow:

Small Amount of Handling.—After the rough material reaches the department it is, in most cases, not removed until the machining is finished; the amount of handling between machines can be reduced to a minimum by such methods as belt or gravity conveyors, slides, or chutes, and small portable tables.

Increased Quality of Supervision.—The Foreman feels that he is really manager of his own little plant producing one piece of work, becomes an expert on the part he is handling, and is continually on the lookout that his department turns out its daily schedule with the least holdup or delay. He interests himself as to the abilities and requirements of the men hired, and studies the possibilities of increasing the production of his machines.

Better Records and Inspection.—Arrangements can be made to have the work pass to inspection benches after certain operations and checked to gages before going on to succeeding operations. A count can here be taken, and credit given to each operator for only the work that passes inspection, or inspection can be handled by floor men who have a certain number of machines to look after, and check the first piece after a set-up, or as often as is required to avoid errors in machining. The work of the department is generally sent through a final inspection before going to assembly or stock, and here a final piece record can be made for the Stock Tracing and Cost Departments.

Facilitates Stock Tracing and Material Records.—In most cases, as there is only one group of machines or department to handle a certain part, the stock chasers and material men can much better control the material and handle records.

Finally, the general foremen and superintendents are better able to study the requirements of the different departments, make necessary improvements, arrange for the trucking and handling of material, devote special attention to the departments that are not producing to schedule, pick out the weak foremen, and keep a much closer check on the entire factory than was possible with the older method of putting all machines of a kind in a department regardless of operations to be done or the amount of handling and record keeping of the material.

This plan of grouping the machines for the sequence of operations is subject to exceptions, for some operations on a part would be difficult to perform in the Machine Department.

Fig. 3—Conveyor Arranged to Minimize Handling

The forging of steels or the carbonizing and hardening operations could hardly be done in the same departments as the machine work; and therefore for this work the best practice has determined on separate departments, in which men specially trained have every opportunity to get the best of results. But in these departments as well, the idea of sequence of operation is followed as nearly as possible. In the Forge Department the hammers, trimming presses, and fires for completing a part, are grouped together, and in the Heat-Treating Department the carbonizing and hardening furnaces, lead pots and quenching tanks are so arranged that the parts require a minimum of handling between operations.

In deciding on the machine-tool location the best location for machining the larger parts, such as crankcases, cylinders and crankshafts, should be considered. The departments for this work should, in most cases, be on the ground floor, to facilitate the handling of the rough material and to take advantage of the foundation to carry the necessary heavy loads of machines and rough stock. The flow of material should be in the easiest course toward the Assembly Departments; the first machine operation being near the Receiving Room for the rough material, and the last operations near the Assembly floors. If it is necessary to use more than the ground floor for machining, lighter machine parts and small assemblies should be handled on the upper floors, leaving the lower floor for the heavy work and final assemblies. With the heavier work machined on the upper floors there is an increase in the handling of the rough material, with subsequent delays in trucking and at elevators, together with necessity of returning the machine parts and also the turnings and scrap to the ground floor.

Floor Plans of Large Factories

The importance of proper layouts is shown by the outline of floor plans used by several large manufacturers.

Fig. 2 represents the floor plans of a plant producing about 150 high-grade cars per day. In room "8" the larger engine parts are machined. All the machines for cylinder operations are arranged in aisle "A"; for crankcases in aisle "B"; for camshafts and connecting-rods in aisle "C"; and for crankshafts in aisle "D." The first-operation machines are located at the end, near room "1," in which the rough stock is received, inspected, cleaned, and moved to first-operation machines. Note the location of spur tracks, unloading dock, long receiving platform and stock rooms.

After the machine operations are completed some of the small parts are fitted at the opposite end of this machine room and the work moved into room "2" for engine assembly.

Labor-Saving Devices

Besides the special arrangement of machine tools and floor layouts, every possible method of labor-saving is utilized: belt conveyors to carry parts, wood or metal chutes and roller conveyors for sliding heavy parts from machine to machine. These relieve the operator of the work of handling stock from and to the floor, conserving his energy and saving time in the operation.

Unnecessary handling of parts at machines and hand trucking about departments should be avoided, as it is a time and labor spender, and causes confusion and loss of material. When material must be taken from one room or floor to another, this can be done by placing it on portable platforms handled with elevating truck, on small tractors with trailers, or on electric trucks.

The cleaning of machine parts is a necessity, either between operations or before sending to assembly or stock. This is done by the use of continuous-conveyor washing machines arranged in the departments as the operation is required, or, in the case of large parts, washing tanks with overhead hoist to handle work from and to truck or conveyor.

The work of designing and building tools and fixtures for performing the machine operations, the gages and methods of inspection, the arrangements of tool cribs and machine repair departments, and the general factory-maintenance work, all are of immense importance in carrying on the daily schedule. All require close study on the part of the management, and capable, experienced men must devote their entire time to departments organized to cover such work.

By so arranging the work that one or more men can do one small operation, then pass the work on to another group, who do their parts, with the material required for each operation conveniently located, the progress of the work is augmented. Each man becomes an expert in his particular operation, making for quality. His movements become automatic, and, as he is paid according to his output, his desire for quantity is increased. This arrangement also permits of more satisfactory inspection and supervision.

Fig. 3 shows a conveyor arranged so that the work for all of the following operations can be taken from and placed onto it as required, minimizing the handling of the heavy unit.

In automobile assembly work it has been found most practicable to assemble the small units, known as sub-

Fig. 4—Flowing on of Varnish by Use of Broad Nozzle

assemblies, in departments by themselves, but conveniently located near the main assembly to avoid excessive trucking. The engine, transmission and axle assemblies are usually handled on track or chain conveyors, starting with the machined casting, placed on an assembly rack, or stand, and moved along by each operator as he finishes his operation, or by a power-driven continuous chain.

In arranging for this progressive assembly the actual time of each operation must be considered so that no part of the work will be held up by the previous operation. The parts and sub-assemblies must be stocked conveniently to each assembly; also any tools required must be within easy reach. One company, as an example, which hand-reams all crankshaft bearings, has the reamers suspended by ropes above the operators with balance weights to hold them up out of the way when not in use. Another company has an overhead trolley circling over the heads of the assemblers with the necessary parts for assembling suspended within reach. As this is an endless conveyor it is kept supplied with parts by one man who fills up the spaces as they pass him. The stock is brought in and placed on a platform near to this man as required.

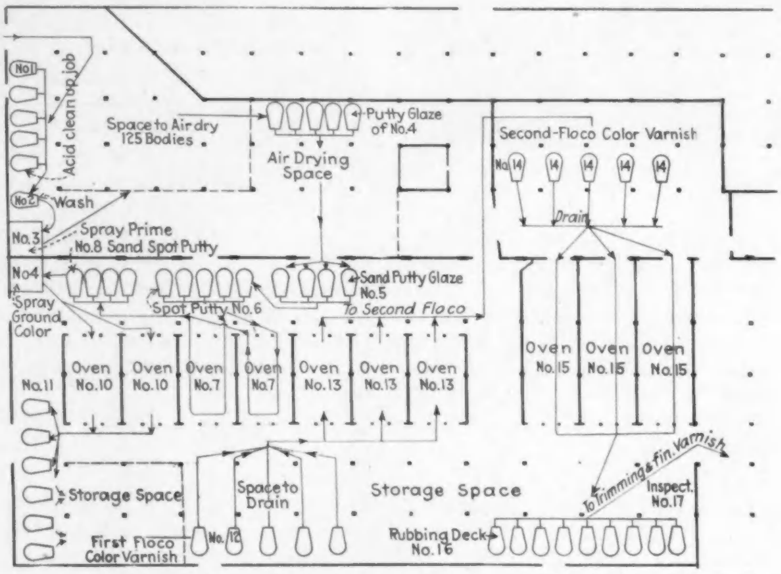


FIG. 5—FLOOR PLAN OF BODY DEPARTMENT USING FLOWING-ON METHODS

It is general practice to have the test room for running-in engines, transmissions or axles located very near the end of the assembly track with convenient methods of moving each unit in for test.

CHASSIS ASSEMBLY

In assembling the various units to the frame, known as chassis assembly, the power-driven conveyor works out most satisfactorily. The frames, after being riveted together, are usually placed on a conveyor, and each unit fitted as the work moves forward. The various units are stored near the track with overhead hoists for carrying and lowering them into frames. Here, too, the work must be arranged and conveyor speed timed so as to allow of proper work at each operation and avoid unnecessary waits between operations.

Fig. 2 shows the arrangement used by one company in assembling chassis. The first operation is started opposite the water and oil-pump department by placing the crankcase on an assembly track carried from overhead, and arranged to be moved along as the operations progress.

The crankshaft and cylinders are brought in at the point on the track where needed, as are also the small assemblies. These have been machined and assembled in the small departments shown at the right and located conveniently to the assembly track.

At the further end of this room the engine is completely assembled and is moved into Room "10," which is directly in line with the end of the assembly track. In this room the engines are tested, adjusted, and moved out at the opposite end into the chassis assembly room "11," at a position near the assembly track where the chassis is ready for its engine.

At the further end of room "11" the chassis assembly is started with the fitting of small parts to the frame, which is moved into the assembly from the stock room at the left. The frame is here placed on a chain-operated conveyor. The spring and axles are fitted as the assembly proceeds, and when ready, the chassis has reached the overhead track from which the engine is lowered into place. The radiator, steering gear and controls are fitted as the chassis is moved on, and it is assembled complete ready for painting when it reaches the end of the room. Before leaving the track the chassis is thoroughly cleaned by a spraying system under a forced-draft hood.

The daily stock requirements of details and assemblies are placed near the assembly track at the position where the parts will be needed as assembly progresses.

A company producing about 100 cars a day has an interesting chassis and final assembly. The frame, lower side up, is started at one end of a long room on a single-track power conveyor. After the springs, axles, and under-pans have been fitted, the chassis reaches the spraying outfit, is painted by two operators working on opposite sides, one a little ahead of the other to avoid the spray, and moved through a long drying oven held at a temperature of about 170 deg. By the time it leaves the oven it is completely dry. Then the wheels are fitted and the chassis, which has now reached the other end of the room, is pushed up a circular track by a large revolving wheel onto the floor above, this operation turning the chassis top side up onto another assembly track.

As the work progresses, the engine is lowered into place, the radiator, steering gear and controls fitted, the body, brought in from its assembly room, is lowered from an overhead hoist and the assembly continued on down to the end of the room. Here the finished car is run out onto an elevator, lowered to the ground and driven out for test. A complete car is in this way produced about every four hours.

The making and upholstering of bodies, the fitting of tops, enameling and painting of fenders and bodies are all important subjects in the manufacturing of the automobile, and here also the idea of handling all work in sequence of operation is carried out by quantity producers. All attention possible is given to floor arrangements and to methods for reducing the operation time and labor.

Dipping and Spraying

For enameling of fenders, running-board aprons and

the smaller parts, dipping is practically the universal method. The parts are suspended to an endless chain conveyor and are dipped into tanks of enamel, passed through a dripping room and then into the baking oven. The process is continued if more than one coat is required. In this work a great deal of attention must be paid to arrangement of tanks and ovens and to the methods of heating to avoid defective work and expensive fires. One company, using this method for enameling fenders, has placed its baking ovens on the roof and has arranged an effective method of rapidly emptying the enamel tanks in case of fire.

The spraying on of the paint by means of high air pressure is in general use for chassis and for all but the final body coats. Recently a new system has come into general use, and when properly installed with special care in selecting the varnishes proves very satisfactory. In this method the paint or varnish is flowed through a broad nozzle, Fig. 4. The body is placed over specially arranged drains, the paint applied at the top and allowed to drip off at the bottom. The excess paint is pumped to tanks above to be used again.

The floor plan for body painting as arranged by one company, which has had particular success in the flowing on of paint, will be of interest.

Before the body is ready for the flowing on of the paint other operations are necessary, as shown. The body in the rough starts at the upper left-hand section of the floor plan shown in Fig. 5, progresses successively through sixteen operations, and is then ready to be upholstered. The time required to carry one body completely through these sixteen operations is six days. This, of course, includes the time in drying ovens. The actual labor requires a total of six hours.

After the work has passed the final inspection it is

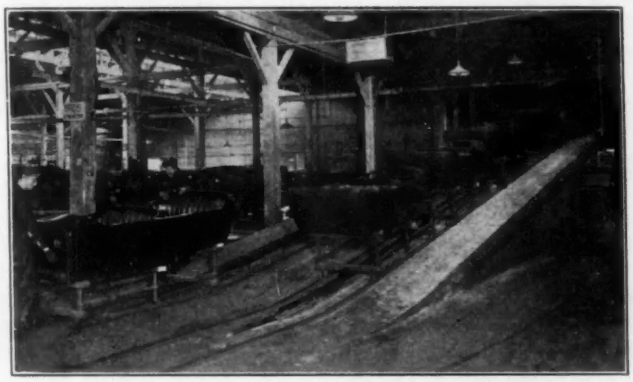


Fig. 6—Conveyor Used in Transferring Bodies

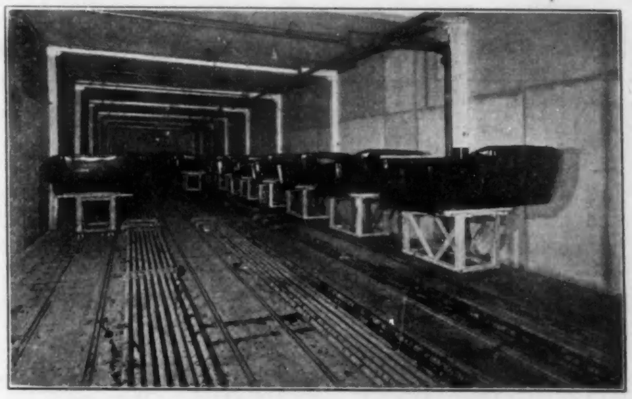


Fig. 7—Ovens Used for Drying Passenger-Car Bodies

taken by means of a conveyor, Fig. 6, up to the upholstering floor and then through to the final flowing on of the varnish, Fig. 4, on the top floor away from dirt and dust, through the long ovens, Fig. 7, after which it comes out finished ready for placing on the chassis for final assembly. It is returned to the assembly floor by the conveyor referred to previously.

Author's Conclusions

Let us then, in closing, sum up the requirements essential to the successful production in large quantities of any satisfactory car or truck, bearing in mind that each plant has its own peculiar problems, made necessary by the design of product, nature of materials used, and the location and arrangement of buildings. These requirements are:

Capable and efficient factory organization.

Proper scheduling and tracing of material to keep ahead of the machine requirements and still maintain a well-balanced, but not over-stocked, inventory.

Best selection and arrangement of machines to produce maximum results with a minimum of effort.

Floor lay-outs for sequence of operations and for progressive assembly.

Most sanitary arrangement of buildings and floors to give agreeable working conditions for employees in order to obtain maximum effort with least labor turnover.

Finally, the education and development of department heads to encourage loyalty and that enthusiasm and cooperation that is absolutely essential to produce desired results and without which, a plant ideal, so far as arrangement and equipment are concerned, would be a complete failure.

Standardization in 1917

THE Standards Committee of the Society met Jan. 9, in New York, with Chairman John G. Utz presiding, to pass on the work accomplished since the June meeting. Some sixty-five different recommendations were submitted for acceptance by the Committee. The majority of these were submitted by the Aeronautic Division, although reports were submitted also by the Motorcycle, Roller-Chain, Tractor, Marine, Data Sheet, Lighting, Tire and Rim, and Miscellaneous Divisions.

The reports as finally accepted are given below. While these have been approved by the Standards Committee, by the Council, and at a Society meeting, there still remains one step to be taken. According to the Constitution of the Society these reports must be submitted to a letter ballot of the voting members before being officially approved as standards or recommended practices. These letter ballots will be sent out to the members in the near future.

The report of the Aeronautic Division includes specifications for cellulose acetate dopes, cellulose nitrate dopes, spar varnish, round high-strength steel wire, non-flexible 19 steel-wire cable, flexible 6 x 7 steel-wire cable, flexible 7 x 7 steel-wire cable, extra flexible 7 x 19 steel-wire cable, reels for cable, tachometer drive, rubber hose for gasoline, plain hexagon nuts (for bodies and wings). The dimensions approved for ball hex, ball castle nuts, castle hexagon nuts, ball hexagon-head bolts and plain hexagon-head bolts at the June meeting were extended to include the 9/16 and ⅝-in. sizes. The clamps and fittings for 3/16 to 3-in. rubber hose* already standardized were approved for aeronautic practice. Complete specifications were recommended for airplane engine testing forms and for engine-weight specifications. Other matters accepted by the Committee are spark-plug shell dimensions and bevel-washer dimensions.

Discussion of Aeronautic Report

In the discussion of the Aeronautic Division report at the Committee meeting a number of minor changes were suggested; these have been incorporated in the report as finally approved. It was decided to refer back the glue specifications to the Division, inasmuch as the test for double shear has been found to be not acceptable, and moreover there seemed to be considerable uncertainty as to the certain other features.

There was considerable discussion as to whether the wires composing the non-flexible 19-steel-wire cable should be coated with tin or should be galvanized. The foreign practice is to have the wire tinned, whereas the United States authorities require galvanized wire. It was also suggested that hot galvanizing should be specified, because it was thought to be better practice. This is especially important in Navy work, when the surface is exposed to salt-air conditions. It was finally voted that the method of galvanizing should be specified by the customer.

Two specifications were submitted on rubber hose for gasoline, these covering a cotton-ply type and a cotton-ply type reinforced with wire. It was voted to change the specifications so that the minimum percentage of rubber should be 25 instead of 32, as first given. There was considerable objection to the requirement that no organic matter other than Para or Plantation Rubber should be used in the preparation of the hose. This was at first amended to read that in case other organic matter was used the amount of such material should be stated. It was said that the rubber manufacturers would refuse to give information of such a nature, and moreover the physical test of the tubing was sufficiently rigid to protect the purchaser. It was finally voted to require that the rubber content should not be less than 25 per cent by weight of Nevea, Wild or Plantation Rubber.

The report of the Motorcycle Division covered matters especially applicable to military motorcycles. The work was first undertaken by an informal committee under the auspices of the Society, and was then continued by the formation of a Motorcycle Division of the Standards Committee. Since the report presented by the Division was prepared the Government had started to design a standardized motorcycle, using the work of the Division in the design. The recommendations were accepted by the Committee without discussion.

A. S. M. E. Cooperation

The Roller-Chain Division has been working with a committee from the American Society of Mechanical Engineers, and the recommendations submitted on nomenclature and dimensions represent the opinions of both the Division and the A. S. M. E. Committee. The roller-chain dimensions are not new sizes, but are simply introduced to furnish sizes most suitable to general work. It was said there were about five times as many sizes of the roller chains in general use as are actually required. A start has been made by designating the pitch, chain width, and roller diameter; it is expected that detail dimensions to correspond can be added later if conditions in the industry warrant such a step. The Division will continue work on tolerances for the chain dimensions, and also proposes to work out with the cooperation of foreign roller-chain manufacturers a standardized series of metric chains.

The Tractor Division, in addition to submitting a recommendation that the tractor drawbar connection should be mounted in a horizontal position, recommended that a number of present S. A. E. standards be used for tractor work. The magneto-mounting dimensions and a condensed tractor specification form were accepted as submitted by the Division.

The Data Sheet Division submitted a report showing progress.

A general index, carefully cross-indexed, has been prepared for the data sheets in the S. A. E. Handbook, and has been mailed to all the members of the Society, together with the latest data sheets.

The Division recommends that separate index sheets or sections of the general index include the general standards and recommended practices that may be approved for use in the following subjects:

Aeronautic, Marine, Motorcycle, Stationary and Farm Engine, and Tractor.

It has been suggested that the present data sheets be enlarged, but after careful consideration the Division unanimously voted to retain the present size for the time being at least.

The Miscellaneous Division had previously suggested that the dimensions for adjustable yoke rod-ends, plain yoke rod-ends, and eye rod-ends, be extended to include

*See report of Miscellaneous Division, Part I, 1916 S. A. E. Transactions or Data Sheet 37, Vol. I, S. A. E. Handbook.

$\frac{7}{8}$ and 1-in. sizes. A standard set of dimensions for mounting bumpers was also offered and accepted. The division submitted a complete set of screw-thread pitches for all diameters from $\frac{1}{4}$ up to 6 in. and over. Regular and fine pitches were specified for each size of bolt, with the result that a systematic standard of screw threads is now offered.

The report of the Marine Division includes dimensions for the flanges for coupling the reverse gear to the engine, for coupling the propeller shaft to the reverse gear, for use with the extended shaft, and for the propeller mounting. These apply to sizes of propellers up to 4-in. shaft diameter. Some objection was made to the construction of the coupling at the end of the reverse gear. It was said that the majority of reverse gears have a straight shaft at the aft end, and that it would be difficult to use a taper fitting at this place. Moreover, it would make it almost impossible to use certain types of flexible couplings. It was suggested that the shaft on the reverse gears should be straight at both ends. In answer to this a cast-iron coupling has already been provided, as well as a straight shaft clamp coupling, which should take care of any objection to the use of the taper shaft.

On account of the lateness of the hour it was necessary to adjourn the meeting of the Standards Committee before taking action on the reports presented by the Marine, Tire and Rim and the Lighting Divisions. The dimensions proposed by the Marine Division and the report of the Tire and Rim Division were accepted at the special meeting of the Standards Committee called during the Society meeting Thursday morning.

It was voted to refer back the dimensions for wood felloe widths for pneumatic truck tires, inasmuch as it was felt that they should receive further attention. The solid-tire demountable-rim equipment which was originally recommended for military-truck use was accepted as a commercial standard as well. The Lighting Division report was accepted by the Standards Committee with some alterations.

All the standards reports were presented at the Society meeting and were adopted for submission to letter ballot of the voting members of the Society.

ATTENDANCE AT STANDARDS COMMITTEE MEETING

Akimoff, Nicholas W.
Allonier, Howard R.
Anderson, Robt. M.
Armstrong, J. R. C.
Aull, Jerome J.
Bachman, B. B.
Bauder, Paul F.
Bergmann, A. C.
Beuret, Emil J.
Birdsall, E. T.
Brate, H. R.
Burnett, R. S.
Chase, Herbert
Chryst, Wm. A.
Clarkson, Coker F.
Clemens, C. E.
Cole, Wm. F.
Colvin, Fred H.
Costello, J. V.
Crane, Henry M.
Dabney, H. D.
Davis, Charles E.
Diefendorf, W. H.
Diffin, F. G.
Dusinberre, S. B.
Ehrman, E. H.
Ericson, Frithiof G.
Farnsworth, Grover
Ferguson, J. C.
Ford, Bruce
Gildner, H. H.
Godley, Chas. E.
Griffith, Leigh M.
Gunn, E. G.
Hale, J. E.
Hanks, M. W.
Harkness, James
Harley, W. S.
Heldt, P. M.
Hinkley, C. C.
Hopewell, Chas. F.
Howard, W. S.
Hulse, E. G.
Jehle, Ferdinand
Jobski, O. H.
Jones, Wm. T.
Kettering, C. F.
Keys, W. C.
Kilborn, K. B.
King, C. B.
Knowles, W. H.
Kratsch, Chas.
Krause, G. A.
LeBlanc, A. T.
Libby, A. D. T.
Livingston, John B.
McBrair, Henry C.
McMahon, H. R.
Manly, Chas. M.
Mayo, V. J.
Modine, A. B.
Morton, H. E.
Myers, C. T.
Newkirk, W. M.
Norton, W. T., Jr.
Orton, Edward, Jr., Major
Parrett, Dent
Pierce, H. S.
Plimpton, R. E.
Randall, D. T.
Reddig, C. E.
Rice, Calvin W.
Rider, F. J.
Rogers, John R.
Rohde, O. J.
Rose, B. H.
Russell, Richard F.
Rys, C. F. W.
Schaefer, C. T.
Schipper, J. E.
Schneider, John S.
Shaw, I. D.
Smith, Lon R.
Smith, Robt. A.
Smith, W. H.
Stagg, H. J., Jr.
Timmerman, A. H.
Tuttle, J. B.
Utz, J. G.
Van Blerck, Jos.
Walker, P. H.
Whitten, F. A.
Williams, Clarence B.
Williams, Louis W.
Wolfe, W. S.

REPORT OF AERONAUTIC DIVISION

(As accepted for submission to mail vote)

Dopes—Cellulose Acetate

The temperature of the doping rooms of airplane factories should be maintained at 70 deg. fahr. The airplane manufacturers should store the dope under a roof.

(1) *Definition.* Dopes for airplane fabrics must consist of a clear, uniform mixture of ingredients and be capable of shrinking the fabric to the degree of tautness desired by the purchaser's inspection. The residual film should be reasonably transparent, and free from white spots, and should give a smooth homogeneous surface, when applied in a horizontal position in an atmosphere not exceeding 65 per cent humidity and 75 deg. fahr. temperature, free from direct draft.

(2) *Viscosity.* The viscosity of the dope must permit of direct application without dilution at a temperature not lower than 60 deg. fahr.

(3) *Coating.* The dope, when dry, must adhere to the fabric with sufficient tenacity to prevent peeling off in sheets. Test strips should show lint attached to the side that has been in contact with the fabric.

(4) *Effect on Tensile Strength and Weight.* Four coats, or an equivalent of the dope, 48 hr. after application, must increase the tensile strength of linen fabrics not less than 25 per cent of the original average strength of warp and filling and of cotton fabric not less than 15 per cent. The increase in weight per square yard of doped fabric should not be less than 2 nor greater than 2.75 oz. The test should be made under standard conditions of humidity and temperature on standard fabrics.

(5) *Acidity.* No mineral acids may be present in the dope, and the amount of free organic acidity figured as acetic acid may not exceed 0.2 per cent. No compounds may be present that would be injurious to the fabric.

(6) *Sulphates.* Dopes that show the presence of free sulphuric acid by the test given below are not acceptable.

(7) *Tetrachlorethane.* Dopes containing tetrachlorethane will not be acceptable for repair work, but will be permissible in factories provided with adequate ventilation.

(8) *Cellulose Acetate.* The cellulose acetates used should contain no free mineral acid and not more than 0.1 per cent free acetic acid, and should be stable. The amount of cellulose acetate shall not be less than 60 grams per liter of dope.

(9) *Solvents.* The volatile solvents employed should present no danger to the workman applying them.

(10) *Inflammability.* Five drops of gasoline dropped on the film that has been dried for 48 hr. and immedi-

ately ignited should have no more serious effect than to char the fabric under the moistened section of the film.

(11) *Exposure Test.* Dopes must comply with the following test: A square frame, 12 by 12 in. inside measurement, is covered on both sides with fabric, the fabric being tacked to the outer side of the frame. The fabric is to be tacked under uniform tension, simulating that employed in airplane manufacture. Four coats, or an equivalent, of dope are to be applied to each side of the frame, each coat being allowed thoroughly to dry before the succeeding coat is applied. The frames are to be exposed on a roof in an unshaded horizontal position, one side being constantly uppermost. After 60 days of constant exposure no spontaneous cracking of the doped surface should be apparent, and after remaining one hour at a temperature of 70 deg. to 80 deg. fahr. the film shall not crack and shall have a decided ring. This test should be made in duplicate and comparatively with a dope that has previously passed the test, and shall be in effect until a mechanical test is adopted.

(12) *Shipment.* Dope shall be shipped in metal cans, metal or wooden barrels, or earthenware containers. Inspection of the containers shall be permitted to insure against the accidental introduction of foreign material. The container shall be marked with the date of manufacture, serial number, gross tare and net weight.

Testing of Dopes

(1) *Acidity.* A 500-cc. beaker, containing about 200 cc. of water is counterbalanced on a large balance. The balance is adjusted to one hundredth gram by adding or removing water. About 10 grams of dope are poured into the water and the increase in weight noted. This is rapidly done to 0.01 gram to diminish solvent loss. The dope is stirred up and allowed to stand 10 to 15 min., with occasional stirring. The liquid is decanted through a rather porous filter into an 800-cc. beaker and 150 cc. of warm water added to the residue. It is allowed to stand 10 to 15 min. with frequent stirring, and poured through the filter into the 800-cc. beaker. The residue is washed with 150 cc. of warm water as before. A few drops of phenolphthalein are added and the solution titrated with twenty-fifth normal caustic soda to a color that persists for one-half minute.

Some dopes, notably those containing much acetone, when poured into water precipitate as a milky solution containing shreds of the acetate. The resulting liquor filters slowly and passes through the filter paper in a cloudy condition. Since the acetate is finely divided, it is practically free from acetic acid, and additional washing is unnecessary. The end-point is not quite so sharp as when all the acetate has been removed, owing to hydrolysis of the suspended material, but is sufficiently accurate for all practical purposes. Absence of mineral acids must be proved by qualitative tests.

(2) *Sulphates.* Twenty grams of cellulose acetate dope are treated with 150 cc. of water in a pressure bottle at 100 deg. cent. for 24 hr. The resulting liquor is filtered and tested for free sulphuric acid.

(3) *Amount of Cellulose Acetate.* Pour 25 grams of the dope into a Petri dish 6 in. in diameter, and evaporate to dryness on the steam bath. Extract the residue with ether in a Soxhlet until all extractive material has been removed. Dry at 60 deg. cent. to constant weight, and weigh.

(4) *Film.* Pour some of the dope on a glass plate and allow to dry spontaneously. The film may be examined for the general characteristics of transparency, coherence, strength and flexibility.

Dopes—Cellulose Nitrate

(1) *Definition.* Dopes for airplane fabrics must consist of a clear, uniform mixture of ingredients, and be capable of shrinking the fabric to the degree of tautness desired by the purchaser inspection. The residual film should be reasonably transparent and free from white spots, and should give a smooth, homogeneous surface when applied in a horizontal position in an atmosphere not exceeding 65 per cent of humidity and 75 deg. fahr. temperature, free from direct draft.

(2) *Viscosity.* The viscosity of the dope must permit of direct application without dilution at a temperature not lower than 60 deg. fahr.

(3) *Coating.* The dope, when dry, must adhere to the fabric with sufficient tenacity to prevent peeling off in sheets. Test strips should show lint attached to the side that has been in contact with the fabric.

(4) *Effect on Tensile Strength and Weight.* Four coats or an equivalent of the dope, 48 hr. after application must increase the tensile strength of linen fabrics not less than 25 per cent of the original average strength of warp and filling and of cotton fabrics not less than 15 per cent. The increase in weight per square yard of doped fabric should not be less than 2 nor greater than 2.75 oz. The test shall be made under standard conditions of humidity and temperature on standard fabrics.

(5) *Acidity.* No mineral acids shall be present in the dope and the amount of free organic acidity figured as acetic acid may not exceed 0.05 per cent. No compounds may be present that would be injurious to the fabric.

(6) *Cellulose Nitrate.* The cellulose nitrate used in the manufacture of dope shall be purified and give a negative potassium iodide test at the end of 20 min., according to the standard Government method for the Abel stability test. The amount of cellulose nitrate used shall be not less than 55 grams per liter of dope.

(7) *Solvents.* The volatile solvents employed shall present no danger to the workman applying them.

(8) *Exposure Test.* Dopes must comply with the following test: A square frame, 12 by 12 in. inside measurement, is covered on both sides with fabric, the fabric being tacked to the outer side of the frame. The fabric is to be tacked under uniform tension, simulating that employed in airplane manufacture. Four coats, or an equivalent, of dope are to be applied to each side of the frame, each coat being allowed thoroughly to dry before the succeeding coat is applied. The frames are to be exposed on a roof in an unshaded horizontal position, one side being constantly uppermost. After 60 days of constant exposure no spontaneous cracking of the doped surface should be apparent, and after remaining one hour at a temperature of 70 to 80 deg. fahr., the film shall not crack and shall have a decided ring. This test shall be made in duplicate and comparatively with a dope that has previously passed the test, and shall be in effect until a mechanical test is adopted.

(9) *Shipment.* Dope shall be shipped in metal cans, metal or wooden barrels or earthenware containers. Inspection of the containers shall be permitted to insure against the accidental introduction of foreign materials. The container shall be marked with the date of manufacture, serial number, gross tare and net weight.

Testing of Dopes

(1) *Acidity.* A 500-cc. beaker, containing about 200 cc. of water, is counterbalanced on a large balance. The balance is adjusted to one-hundredth gram by adding or removing water. About 10 grams of dope are poured

into the water and the increase in weight noted. This is rapidly done to 0.01 gram to diminish solvent loss. The dope is stirred up and allowed to stand 10 to 15 minutes with occasional stirring. The liquid is decanted through a rather porous filter into an 800-cc. beaker, and 150 cc. of warm water added to the residue. It is allowed to stand 10 to 15 minutes with frequent stirring, and poured through the filter into the 800-cc. beaker. The residue is washed with 150 cc. of warm water as before. A few drops of phenolphthalein are added and the solution titrated with twenty-fifth-normal caustic soda to a color that persists for one-half minute. Any satisfactory substitute method will be permissible on approval.

(2) *Amount of Cellulose Nitrate.* Pour 25 grams of the dope into 100 grams of chloroform, stirring constantly. Extract in a Soxhlet with chloroform until all material possible has been removed. Dry at 60 deg. cent. to constant weight, and weigh.

(3) *Film.* Pour some of the dope on a glass plate and allow to dry spontaneously. The film may be examined for the general characteristics of transparency, coherence, strength, and flexibility.

Spar Varnish Specification

Composition and General Properties. The material shall be the best long oil varnish, suitable for application on wood, "doped" linen or cotton, and metal, and resistant to air, light and water. The manufacturer is given the greatest latitude in the selection of raw materials and process of manufacture in order to produce a product of the highest quality.

Physical Characteristics. The material shall comply with the following requirements:

(1) It shall be clear and transparent.

(2) Its color shall be no darker than a standard color solution, made by dissolving 6 grams of pure powdered potassium bichromate in 100 cc. of pure concentrated sulphuric acid (specific gravity 1.84). Gentle heat may be used, if necessary, to secure a perfect solution of the bichromate. The color comparison will be made by placing the varnish and the standard color solution in clear, thin-walled glass tubes of the same diameter, 1.5 to 2 cm. (5/8 to 13/16 in.) to a depth of at least 2.5 cm. (1 in.) and comparing the colors by looking through the tubes, across the column of the liquid by transmitted light.

(3) It shall not flash below 35 deg. cent. (95 deg. fahr.) in an open tester.

(4) The varnish will be flowed on one side of a 10 by 15-cm. (approx. 4 by 6 in.) panel of bright tin. The panels* shall be approximately 0.3 to 0.4 mm. (0.0125 to 0.0158 in.) thick, and shall be cleaned thoroughly with benzol. When a panel is held in a vertical position and maintained at a temperature of 21 to 32 deg. cent. (70 to 90 deg. fahr.), the varnish shall set to touch at a point not less than 2.5 cm. (1 in.) from the side or top edges of the film, in not more than 5 hr.; and shall dry hard in not more than 24 hr. to a clear, hard, glossy film. The panel will then be allowed to dry for a further period of not less than 5 days and then brought to a temperature of not less than 21 deg. cent. (70 deg. fahr.) nor more than 24 deg. cent. (75 deg. fahr.) and maintained at this temperature for not less than 15 min. The panel, with the varnished side on the outside, will then be bent double rapidly over a rod 3 mm. (1/8 in.) diameter. The varnish film shall show no cracking or flaking at the point of bending.

*The base metal must weigh from 90 to 100 lb. per standard box of 112 sheets, 14 by 20-in. No. 30 to 28 U. S. standard plate gage.

(5) The varnish will be applied to a basswood panel which has been filled with one coat of drop black in oil thinned with turpentine and drier, and allowed to dry for not less than 10 days before applying the varnish. It shall have suitable body to give proper brushing, flowing and covering properties. The first coat of varnish will be allowed to dry 48 hr., then lightly sandpapered, a second coat applied and allowed to dry 72 hr. The panel will then be inclined at an angle of about 45 deg. and a gentle stream of cold tap water allowed to flow down the middle of the panel for 18 hr. After wiping off with a chamois skin, any deposits due to the tap water, the varnish shall show no whitening, dulling or other defects. A small stream of boiling distilled water will then be allowed to flow down another portion of the panel for 20 minutes. The water will be siphoned through a small glass tube directly from a container in which it is boiling, onto the surface of the panel, in such a manner that there will be no appreciable lowering of the temperature of the water before it touches the varnish film. The siphon delivery tube will be in a plane nearly parallel to the plane of the panel, so that the impact of the water will not tend to break the film. The varnish shall show no appreciable whitening and no more than a very slight dulling, or other indications of marked deterioration, either when observed immediately after removing from the water, or after drying for 2 hours.

(6) The varnish will be applied in three coats to two unfilled panels of maple wood, not less than 14 by 45 by 2 cm. (5½ by 18 by ¾ in.), allowing three days for the drying of each coat. The first coat, after drying indoors for 3 days will be sandpapered lightly with No. 00 sandpaper before the application of the next coat. The second and third coats will not be sandpapered or rubbed, and the duplicate panels will be exposed outdoors, 45 deg. to the vertical, facing south, three days after the application of the finishing coat. The backs and edges of the panels will also be varnished with three coats of the same sample, but for these surfaces the details of the method of application as given need not be adhered to, and the effects of exposure on these surfaces will not be considered.

On this test, the varnish shall show satisfactory durability and weather resistant properties. In cases where the award of a contract cannot be delayed for the results of the exposure test, award may be made on the basis of the other requirements; but a varnish of any specific brand that does not show up satisfactorily on exposure test may be omitted from consideration in future awards, and a preliminary submittal of samples for making exposure tests may be called for.

Note—In general, results comparable to those given by the above method may be obtained by flowing one coat of varnish on duplicate panels of bright tin thoroughly cleaned with benzol, allowing to dry 48 hr., and then immersing one of the panels in distilled water at room temperature for 18 hr.; and the other panel in boiling distilled water for 15 minutes. But the test on wood should be made in all cases when there is any doubt regarding the resistance of the varnish to water.

Round High Strength Steel Wire

This specification covers solid high strength steel wire, round section, used in the construction of aircraft and in which flexibility is of minor importance.

Workmanship and Finish. The wire shall be cylindrical and smooth and may show no evidence of scrapes, splints, cold shuts, rough tinning, or other defects not in accordance with best commercial practice.

Tensile Test. Samples for the tensile test shall be not less than 15 in. long and free from bends and kinks. In making tensile tests on aircraft wire, the distance between jaws of testing machine, with the sample in place and before test, shall be 10 in. The wire must not break at less than the amount specified in the accompanying table, which is a part of this specification.

Torsion Test. Samples for the torsion test shall be straight and not less than 10 in. long. The sample shall be gripped by two vises 8 in. apart; one vise shall be turned uniformly at a speed not exceeding 60 r.p.m. (on the larger sizes of wire this speed shall be reduced sufficiently to avoid undue heating of the wire). One vise shall have free axial movement in either direction. All wire shall be required to withstand a number of complete turns, which are to be agreed upon between the purchaser and the manufacturer.

Bend Test.—Samples for bend test shall be straight and not less than 10 in. long. One end of the sample shall be clamped between jaws having their upper edges rounded with 3/16 (0.188) in. radius. The free end of the wire shall be held loosely between two guides and bent 90 deg. over one jaw; this is to be counted as one bend. On raising to a vertical position the count will be two bends. The wire shall then be bent to the other side, and so forth, alternating to fracture. The minimum number of bends required is stated in accompanying table.

Wrapping Test. This is to be made on at least 10 per cent of the total number of coils offered for inspection at one time. The wire is wrapped around its own diameter eight consecutive turns with a pitch substantially equal to the diameter of the wire and then unwrapped, maintaining the free end at approximately 90 deg. with the mandrel. It must stand this test without fracture. Because of the possibility of personal error in making this test, failure on one test is not considered conclusive, and if required to do so the inspector shall make at least one, but no more than two, additional tests on the sample of wire. If any of these tests are successful, the material shall be passed as satisfactory in this respect.

DATA FOR ROUND HIGH STRENGTH STEEL WIRE

American Wire Gage No.	Diameter, In.	Weight, Lb./100 Ft.	Number of Bends Through 90 Deg.	Minimum Breaking Strength, Lb.	Tensile Strength, Lb./Sq. In.
6	0.162	7.01	5	4,500	219,000
7	0.144	5.56	6	3,700	229,000
8	0.129	4.40	8	3,000	233,000
9	0.114	3.50	9	2,500	244,000
10	0.102	2.77	11	2,000	244,000
11	0.091	2.20	14	1,620	254,000
12	0.081	1.744	17	1,300	252,000
13	0.072	1.383	21	1,040	255,000
14	0.064	1.097	25	830	258,000
15	0.057	0.870	29	660	259,000
16	0.051	0.690	34	540	264,000
17	0.045	0.547	42	425	267,000
18	0.040	0.434	52	340	270,000
19	0.036	0.344	70	280	275,000
20	0.032	0.273	85	225	280,000
21	0.028	0.216	105	175	284,000

Selection of Test Specimen. A tensile, a torsion and a bend test shall be made on each end of each piece or coil of wire. When an individual coil of wire is to be divided into smaller coils to meet special requirements, it is sufficient to make one test on the original coil and to cut and seal the small coils in the presence of the inspector.

Dimensions and Tolerances. All wire for this purpose shall be furnished in decimal sizes corresponding to the American wire gage (Brown & Sharpe gage).

A permissible variation of 0.002 in. above gage on all sizes will be accepted, but no wire will be accepted having a variation of more than 0.0005 in. below gage.

NON-FLEXIBLE 19 STEEL WIRE CABLE

This specification covers high strength 19 steel wire cable used in the construction of aircraft and in which flexibility is of minor importance.

Manufacture. The steel wires composing the cable shall be laid around the center wire in one or two layers as required by the number of wires in the cable with a left-hand (counter-clockwise) pitch and with a length of lay not to exceed eleven times the diameter of the cable or not less than nine times the diameter of the cable.

Wires composing the cable shall be uniformly coated with pure tin or galvanized* to solder readily.

The joints in wires composing the cable shall be brazed in a gas fire. Tucked in, welded or twisted joints will not be permitted. No two brazed joints in individual wires shall be closer than 150 ft. to one another in the completed cable. All brazed joints in wires shall be tinned. Exposed brass at joints shall not constitute cause for rejection.

Workmanship and Finish. Each length of cable is to be evenly laid and free from kinks, loose wires or other irregularities. The cable shall remain in this condition when unwound from the reel or bent around a standard thimble, proper precautions being taken to secure the ends.

Tensile Test. A tensile test shall be made upon each reel of cable purchased of a size.

Samples of cable for testing for tensile strength shall be not less than 24 in. long. In making tensile tests the distance between jaws of testing machine, with sample in place and before test, shall be not less than 10 in.

Samples for tensile test may be clamped in the jaws of the testing machine in the usual manner to facilitate testing, but in case of failure or dispute on individual tests, and at the request of the manufacturer, check tests shall be made by socketing the samples with pure zinc.

Cable for use in the construction of aircraft shall meet the required breaking strength specified in the table.

Bend Test. One bend test is to be made on a sample cut from each reel of cable of a given size. Each sample must be bent once around its own diameter and straightened again at least 20 times in succession in the same direction of bending without any of the wires breaking.

Torsion Test. This is to be made on one wire from each sample of cable taken for tensile test. The wire is to be gripped by two vises 8 in. apart. One vise shall be turned uniformly at as high a rate of speed as possible without perceptibly heating the wire. One vise shall have free axial movement in either direction.

The number of complete turns which the wire shall stand is determined by the relation:

Number of turns $= 2.2 \div$ dia. in inches.

Failure of one piece of wire to show full number of turns specified in the above torsion test shall not be considered cause for rejection, but in such case two additional tests shall be made on two more wires from the same sample of cable, and if both samples meet the requirements of the specifications the cable shall be accepted in this respect.

Dimensions and Tolerances. There shall be no permissible variation in gage below size. Cable having a diameter of 0.031 (1/32) to 0.156 (5/32) in., inclusive, shall have a permissible variation of 10 per cent above

*If the galvanized coating is used, the method is to be specified by the purchaser.

size, and cable having a diameter of 0.188 (3/16) to 0.375 (3/8) in., inclusive, shall have a permissible variation of 7 per cent above size.

WEIGHTS, SIZES AND STRENGTH OF NO. 19 CABLE

Diameter, In.	Minimum Breaking Strength, Lb.	Approx. Weight, Lb./100 Ft.
0.312 (5/16)	12,500	20.65
0.250 (1/4)	8,000	13.50
0.218 (7/32)	6,100	10.00
0.188 (3/16)	4,600	7.70
0.156 (5/32)	3,200	5.50
0.125 (1/8)	2,100	3.50
0.109 (7/64)	1,600	2.60
0.094 (3/32)	1,100	1.75
0.078 (5/64)	780	1.21
0.062 (1/16)	500	0.78
*0.031 (1/32)	185	0.30

*7 wire.

FLEXIBLE 6 x 7 STEEL WIRE CABLE

This specification covers high strength 6 x 7 flexible steel wire cable used in the construction of aircraft and in which flexibility is important.

Manufacture. The steel wires composing the individual strands of the cable shall be laid concentrically around the center wire in one layer of six wires with a left-hand (counter-clockwise) pitch or lay. The cable itself shall be constructed by twisting six of these strands composed of seven wires each around a cotton center with a right-hand (clockwise) pitch or lay of six to eight times the diameter of the whole.

Wires composing the cable shall be uniformly coated with pure tin to solder readily.

Joints in wires in cable having a diameter of 0.156 (5/32) in. and larger shall be brazed in a gas fire. In cable having a diameter of 0.125 (1/8) in. or less, wires may be joined either by brazing or twisting, at the manufacturer's convenience. Tucked-in or welded joints are not permitted. No two joints in individual wires shall be closer than 30 ft. to one another in the completed cable. All brazed joints shall be tinned. Exposed brass at joints shall not constitute cause for rejection.

Workmanship and Finish. Each length of cable is to be evenly laid, and free from kinks, loose wires or other irregularities. The cable shall remain in this condition when unwound from the reel or bent around a standard thimble, proper precautions being taken to secure the ends.

Tensile Test. A tensile test shall be made upon each individual reel of cable purchased of a size.

Samples of cable for testing for tensile strength shall be not less than 24 in. long. In making tests the distance between jaws of testing machine with sample in place and before test shall be not less than 10 in.

Samples for tensile test may be clamped in the jaws of the testing machine in the usual manner to facilitate testing; but in case of failure or dispute on individual tests and at the request of the manufacturer check tests shall be made by socketing the samples with pure zinc.

Cable for use in the construction of aircraft shall meet the required breaking strength specified in the table.

Bend Test. One bend test is to be made on a sample cut from each reel of cable of a given size. Each sample must be bent once around its own diameter and straightened again at least 20 times in succession in the same direction of bending without any of the wires breaking.

Torsion Test. This is to be made on one wire from each sample of cable for tensile test. The wire is to be gripped by two vises 8 in. apart. One vise shall be turned uniformly at as high a rate of speed as possible without perceptibly heating the wire. One vise shall have free axial movement in either direction.

The number of complete turns which the wire shall stand is determined by the relation:

Number of turns = 2.2 ÷ dia. in inches.

Failure of one piece of wire to show full number of turns specified in this torsion test shall not be considered cause for rejection, but in such case two additional tests shall be made on two more wires from the same sample of cable, and if both samples meet the requirements of the specifications the cable shall be accepted in this respect.

Dimensions and Tolerances. There shall be no permissible variation in gage below size. Cable having a diameter of 1/16 to 3/32 in., inclusive, shall have a permissible variation of 12 per cent above size; cable having a diameter of 1/8 to 3/16 in., inclusive, shall have a permissible variation of 10 per cent above size, and cable having a diameter of 7/32 to 3/8 in., inclusive, shall have a permissible variation of 7 per cent above size.

WEIGHTS, SIZES AND STRENGTH OF 6 X 7 CABLE

Diameter, In.	Minimum Breaking Strength, Lb.	Approx. Weight, Lb./100 Ft.
0.312 (5/16)	7,900	15.00
0.250 (1/4)	5,000	9.50
0.218 (7/32)	4,000	7.43
0.188 (3/16)	2,750	5.30
0.156 (5/32)	2,200	4.20
0.125 (1/8)	1,150	2.20
0.109 (7/64)	830	1.50
0.094 (3/32)	780	1.30
0.078 (5/64)	480	0.83
0.062 (1/16)	400	0.73

FLEXIBLE 7 x 7 STEEL WIRE CABLE

This specification covers high strength 7 x 7 flexible steel wire cable used in the construction of aircraft and in which flexibility is important.

Manufacture. The steel wires composing the individual strands of the cable shall be laid concentrically around the center wire in one layer of six wires with a left-hand (counter-clockwise) pitch or lay. The cable itself shall be constructed by twisting six of these strands composed of seven wires each around a seventh strand of the same construction and material with a right-hand (clockwise) pitch and with a length of lay of six to eight times the diameter of the whole.

Wires composing the cable shall be uniformly coated with pure tin to solder readily.

Joints in wires in cable having a diameter of 0.156 (5/32) in. and larger shall be brazed in a gas fire. In cable having a diameter of 0.125 (1/8) in. or less, wires may be joined either by brazing or twisting, at the manufacturer's convenience. Tucked-in or welded joints are not permitted. No two joints in individual wires shall be closer to one another in the completed cable than 30 ft. All brazed joints shall be tinned. Exposed brass at joints shall not constitute cause for rejection.

Workmanship and Finish.—Each length of cable is to be evenly laid, and free from kinks, loose wires, or other irregularities. The cable shall remain in this condition when unwound from the reel or bent around a standard thimble, proper precautions being taken to secure the ends.

Tensile Test. A tensile test shall be made upon each individual reel of cable purchased of a size.

Samples of cable for testing for tensile strength shall be not less than 24 in. long. In making tests the distance between jaws of testing machine with sample in place and before test shall be not less than 10 in.

Samples for tensile test may be clamped in the jaws of the testing machine in the usual manner to facilitate testing; but in case of failure or dispute on individual tests and at the request of the manufacturer, check tests shall be made by socketing the samples with pure zinc.

Cable for use in the construction of aircraft shall meet the required breaking strength specified in the table.

Bend Test. One bend test is to be made on a sample cut from each reel of cable of a given size. Each sample must be bent once around its own diameter and straightened again at least 20 times in succession in the same direction of bending without any of the wires breaking.

Torsion Test. This is to be made on one wire from each sample of cable for tensile test. The wire is to be gripped by two vises 8 in. apart. One vise shall be turned uniformly at as high a rate of speed as possible without perceptibly heating the wire. One vise shall have free axial movement in either direction.

The number of complete turns which the wire shall stand is determined by the relation:

Number of turns = 2.2 ÷ dia. in inches.

Failure of one piece of wire to show full number of turns specified in the above torsion test shall not be considered cause for rejection, but in such case two additional tests shall be made on two more wires from the same sample of cable, and if both samples meet the requirements of the specifications the cable shall be accepted in this respect.

Dimensions and Tolerances. There shall be no permissible variation in gage below size. Cable having a diameter of 1/16 to 3/32 in., inclusive, shall have a permissible variation of 12 per cent above size; cable having a diameter of ⅛ to 3/16 in., inclusive, shall have a permissible variation of 10 per cent above size, and cable having a diameter of 7/32 to ⅜ in., inclusive, shall have a permissible variation of 7 per cent above size.

WEIGHTS, SIZES AND STRENGTH OF 7 X 7 CABLE

Diameter, In.	Minimum Breaking Strength, Lb.	Approx. Weight, Lb./100 Ft.
0.312 (5/16)	9,200	16.70
0.250 (¼)	5,800	10.50
0.218 (7/32)	4,600	8.30
0.188 (3/16)	3,200	5.80
0.156 (5/32)	2,600	4.67
0.125 (⅛)	1,350	2.45
0.094 (3/32)	920	1.45
0.078 (5/64)	550	0.93
0.062 (1/16)	480	0.81

EXTRA FLEXIBLE 7 X 19 STEEL WIRE CABLE

This specification covers high strength 7 x 19 extra flexible steel wire used in the construction of aircraft and in which extra flexibility is important.

Manufacture. The steel wires composing the individual strands of cable shall be laid concentrically around the center wire in one layer of six wires and another, or outer layer, of twelve wires with a left-hand (counterclockwise) pitch, the lay or pitch of both layers being of the same length; the cable itself shall be constructed by twisting six of these strands composed of nineteen wires each around a seventh strand of the same construction and material with a right-hand (clockwise) pitch or lay of six to eight times the diameter of the whole.

It is to be understood that the strand composing this cable must not necessarily be composed of wires all of the same diameter.

Wires composing the cable shall be uniformly coated with pure tin to solder readily.

Joints in wires in cable having a diameter of 0.188 (3/16) in. and larger shall be brazed in a gas fire. In cable having a diameter of 0.156 (5/32) in. or less, wires may be joined either by brazing or twisting at the manufacturer's convenience. Tucked-in or welded joints are not permitted. No two joints in individual wires shall be closer than 30 ft. to one another in the completed cable.

Workmanship and Finish. Each length of cable is to be evenly laid and free from kinks, loose wires, or other irregularities. The cable shall remain in this condition when unwound from the reel or bent around a standard thimble, proper precautions being taken to secure the ends.

Tensile Test. A tensile test shall be made upon each individual reel of cable purchased of a size.

Samples of cable for testing for tensile strength shall be not less than 24 in. long. In making tensile tests the distance between jaws of testing machine with sample in place and before test shall be not less than 10 in.

Samples for tensile test may be clamped in the jaws of the testing machine in the usual manner to facilitate testing, but in case of failure or dispute on individual tests, and at the request of the manufacturer, check tests shall be made by socketing the samples with pure zinc.

Cable for use in the construction of aircraft shall meet the required breaking strength specified in the table.

Bend Test. One bend test is to be made on a sample cut from each reel of cable of a given size. Each sample must be bent once around its own diameter and straightened again at least 20 times in succession in the same direction of bending without any of the wires breaking.

Torsion Test. This is to be made on one wire from each sample of cable taken for tensile test. The wire is to be gripped by two vises 8 in. apart; one vise shall be turned uniformly at as high a rate of speed as possible without perceptibly heating the wire. One vise shall have free axial movement in either direction.

The number of complete turns which the wire shall stand is determined by the formula:

Number of turns = 2.2 ÷ dia. in inches.

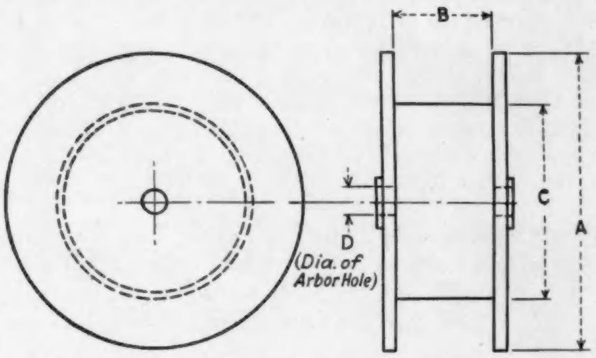
Failure of one piece of wire to show full number of turns specified in the above torsion test shall not be considered cause for rejection, but in such case two additional tests shall be made on two more wires from the same sample of cable, and if both samples meet the requirements of the specification the cable shall be accepted in this respect.

Dimensions and Tolerances. There shall be no permissible variation in diameter below size. Cable having a diameter of 0.125 (⅛) to 0.187 (3/16) in., inclusive, shall have a permissible variation of 10 per cent above size, and cable having a diameter of 0.218 (7/32) to 0.375 (⅜) in., inclusive, shall have a permissible variation of 7 per cent above size.

WEIGHTS, SIZES AND STRENGTH OF 7 X 19 CABLE

Diameter, In.	Minimum Breaking Strength, Lb.	Approx. Weight, Lb./100 Ft.
0.375 (⅜)	14,400	26.45
0.344 (11/32)	12,500	22.53
0.312 (5/16)	9,800	17.71
0.281 (9/32)	8,000	14.56
0.250 (¼)	7,000	12.00
0.218 (7/32)	5,600	9.50
0.188 (3/16)	4,200	6.47
0.156 (5/32)	2,800	4.44
0.125 (⅛)	2,000	2.88

Reels for Aircraft Cable



Diameter Cable, In.	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
	1,000 Feet				3,000 Feet				5,000 Feet				10,000 Feet			
1/32	12	4	8	1⅛	12	4	8	1⅛	12	4	8	1⅛	16	4	10	1⅛
1/16	12	4	8	1⅛	12	4	8	1⅛	16	4	10	1⅛	16	7	12	1⅛
5/64	12	4	8	1⅛	16	4	10	1⅛	16	7	12	1⅛	16	10	8	1⅛
3/32	12	4	8	1⅛	16	4	10	1⅛	16	7	12	1⅛	16	10	8	1⅛
7/64	16	4	10	1⅛	16	7	12	1⅛	16	10	8	1⅛	18	10	8	1⅛
1/8	16	4	10	1⅛	16	7	12	1⅛	16	10	8	1⅛	24	10	10	1⅛
9/64	16	7	12	1⅛	16	10	8	1⅛	24	10	10	1⅛	24	16	10	2⅛
5/32	16	7	12	1⅛	16	10	8	1⅛	24	10	10	1⅛	24	16	10	2⅛
3/16	18	7	12	2⅛	18	10	8	2⅛	24	10	10	2⅛	24	16	10	2⅛
7/32	18	7	12	2⅛	18	10	8	2⅛	24	10	10	2⅛	32	20	16	3⅛
1/4	18	10	10	2⅛	24	10	10	2⅛	32	18	16	2⅛	36	22	18	3⅛
5/16	18	10	10	2⅛	24	10	10	2⅛	32	18	16	2⅛	36	22	18	3⅛
11/32	18	10	8	2⅛	32	16	16	2⅛	32	20	16	3⅛	50	16	26	3⅛
3/8	18	10	8	2⅛	32	16	16	2⅛	32	20	16	3⅛	50	16	26	3⅛

Dimensions given in inches.

Engine End. The lower or engine end is finished with a cylindrical end with a single integral key.

Casing. The casing is to be of flexible metallic tubing, covered with whip-cord braid and impregnated to prevent oil leakage; similar to sample, or covered with other material that will be equally flexible, oil-tight, and free from stretching and of no greater weight than the whip-cord braid covering the casing. The outside diameter of casing to be over braid to be about 7/16 in.; the inside diameter of casing to be about ¼ in. The ends of the casing are finished alike, as shown in the accompanying sketches. The screw-threaded sockets covering the whip-cord braid are screwed in place and set with shellac or other suitable material to form an oil-tight and permanent connection.

Shaft-End. The shaft-end at the engine is drilled and slotted to fit the tachometer shaft end, allowing at least 1 in. for end-play. More play than this may be required where the drive-shaft is more than 6 ft. in length, the amount to be determined experimentally.

Drive-Shaft. This is to be of helical wire-wound construction, with core wires.

Spindle. The tachometer spindle is finished square to fit the square socket on the drive-shaft.

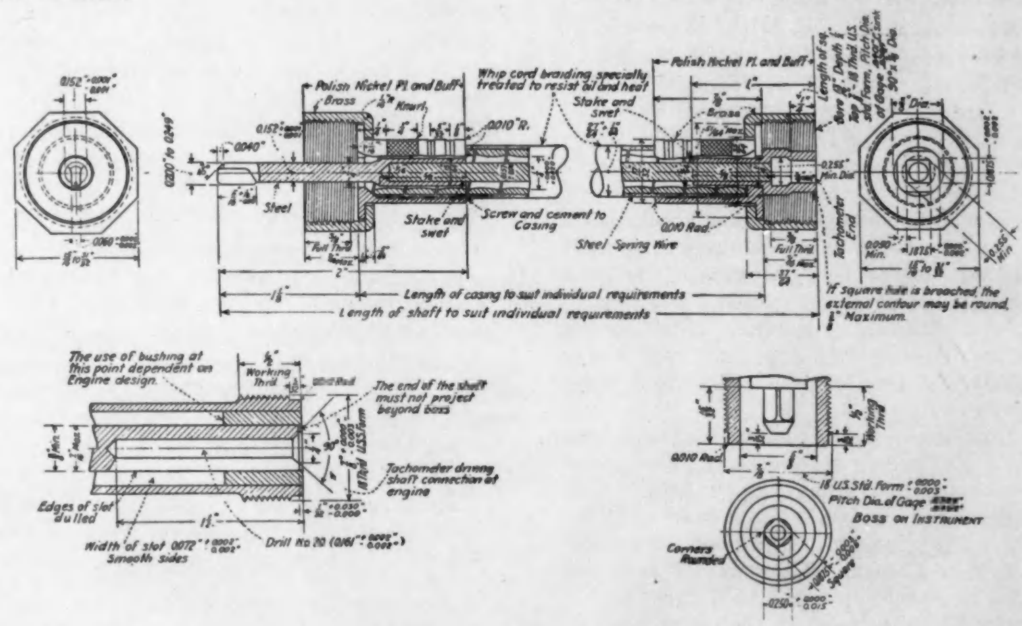
Drive-Shaft. This will rotate at one-half crankshaft speed.

End Nuts. The size and contour of exterior circumference of end nuts is optional, but a 15/16-in. octagon is recommended.

Rubber Hose for Gasoline—Type No. 1—Cotton Ply

Part I. Technical

The gasoline hose must consist of rubber and cotton



Details of Tachometer Drive for Airplane Engines

Round, solid, high-strength steel wire is to be shipped in coils or bundles protected with waterproof wrapping of paper.

In making racks for these reels allow 4 in. greater width than the traverse (*B*) specified.

Tachometer Drive

Instrument End. The upper or instrument end of the shaft has a squared socket, made integral with a shoulder that forms a thrust bearing.

constructed according to the following specifications. The quality of the finished hose must be uniformly good throughout.

Inner Tube. This is to be made of rubber free from flaws or cracks and of a quality conforming to the conditions laid down in this specification.

When of an internal diameter of ¾ in. or less, this inner tube must be seamless. Tubes of larger internal diameter may be made from rubber sheet, in which case

they must consist of at least two turns, and be formed into a complete tube in the process of manufacture.

Cotton Plies. The cotton shall consist of either braided or canvas plies which shall comply with the requirements given in the following table:

Internal Dia., In.	Min. No. Plies
Up to and including 5/8	2
11/16 to 1½ inclusive	3
Above 1½	4

Outer Cover. This is to be made of rubber of the same quality as that used for the inner tube, and of good workmanship and finish.

Dimension Limit. The internal diameter of the hose must not vary more than plus or minus 3 per cent of the given internal diameter.

Length of Hose. The manufacturer, when quoting or when acknowledging an order for this class of hose, must state the lengths in which it can be supplied. The hose should be supplied in the maximum lengths possible.

Physical Properties. By "flexibility" is meant ability to bend without kinking. When hose of internal diameter (y) is bent around a cylinder having a diameter equal to x times the external diameter of the hose, as shown in the following table, the external diameter of the hose must not increase or diminish by more than 10 per cent:

Internal Dia. (y) In.	x
Less than ½	8
½ to ¾	12
13/16 to 1⅛	14
Above 1⅛	16

The hose, after having been filled with gasoline for 2 hr., must withstand, without showing defects, a minimum internal hydraulic pressure (p), depending upon the internal diameter (d) of the hose.

Internal Dia. (d) In.	Min. Pressure (p) lb./sq. in.
Up to ½ inclusive	160
9/16 to 1 inclusive	140
1 1/16 to 1½ inclusive	120
1 9/16 to 2 inclusive	100
Above 2	80

Chemical Properties. The rubber content shall not be less than 25 per cent by weight of plantation or wild hevea rubber. The amount of free sulphur in the tube, cover, or friction compound shall not exceed 1 per cent.

Dry Heat Test. A 3-in. piece of the hose, after having been placed in an air oven at 132 deg. cent. for 2 hr., must show, when cool, no tendency to crack, and must not be tacky.

Permeability to Gasoline. A 14-in. length of the hose is held vertically and plugged at the bottom. The upper end is fitted with a glass tube about 18 in. long. The hose so arranged is filled with gasoline* to a head of 12 in. above the top of the acting length of the hose. The acting length of the rubber hose is 12 inches. The upper end of the glass tube is loosely closed with a cork.

During the first 24 hr. the level of the gasoline will fall comparatively rapidly. The loss is made good by frequent additions from a known volume of gasoline, care being taken that the level of the gasoline in the glass tube does not fall by more than 3 in. at any time. The test is to last for 72 hr., and the loss of gasoline during the third 24 hr. must not exceed 100 cc. per sq. ft. of the original internal surface of the hose.

*The specific gravity of the gasoline used in this test should be between 0.710 and 0.725 at 15.5 deg. cent. (60 deg. fahr.); 65 per cent of it must distill over at 100 deg. cent. (212 deg. fahr.) from a distillation flash when the bulb of the thermometer is just below the side tube.

Immersion in Gasoline. A 3-in. piece of the hose is boiled for 1 hr. (using a reflex condenser) in gasoline similar to that used for the permeability test. The gasoline is allowed to cool down. Twenty-four hours later the test piece is removed from the gasoline and examined without delay, as follows:

The internal diameter at the point of greatest constriction is measured by means of rod gages. From this measurement the area of the bore is calculated. This must not differ from the original by more than 25 per cent.

The test-specimen is then cut longitudinally into halves, and the adhesion between rubber and cotton carefully examined. The adhesion must be of such a character that the rubber can only be stripped from the cotton by hand with difficulty.

Immersion in Oil. A 3-in. piece of the hose is immersed in oil, approved by the purchaser, at a temperature of 100 deg. cent. for 8 hr., and for a further period of 24 hr. at ordinary temperature. The oil is then wiped from the surface of the hose. The decrease of internal diameter shall be less than 10 per cent.

The flexibility and elasticity of the rubber must not be diminished and there must be no tendency of the rubber to separate from the cotton.

Part II. Inspection

Test-Specimens. The purchaser will decide where the tests are to be carried out. All test-specimens are to be cut in the presence of the inspector and are to be marked as he may direct.

For the purpose of testing, a representative sample will be cut from each 1000 ft. of hose or fraction thereof, and the tests will proceed in accordance with the purchaser's instructions.

Rejections. If any sample fails to comply with any of the above tests, the hose represented thereby will be rejected.

Marking. Accepted and rejected material must be marked as directed by the inspector.

Part III. Special Conditions

Depreciation. The manufacturer must bear the cost of the depreciation in value of any rejected material due to test-specimens being cut therefrom.

Rejected Material. The manufacturer must not supply any material that has previously been rejected by any Government Department, without giving full written particulars of the previous rejection to the inspector who is inspecting to this specification.

Rubber Hose for Gasoline—Type No. 2
Cotton Ply Reinforced with Wire

Part I. Technical

The gasoline hose must consist of rubber and cotton constructed in the following manner, and the quality of the finished hose must be uniformly good throughout.

Inner Tube. This shall consist of a canvas tube supported by a helix of oil-tempered steel wire of not less than 0.020 in. diameter, spaced not less than five turns per inch. The rubber tube shall be placed between this inner cotton tube and the cotton plies.

Cotton Plies. The cotton shall consist of either braided or canvas plies, which shall comply with the requirements of the following table. The inner cotton tube shall not be considered one of the plies specified.

Internal Dia., In.	Min. No. Plies
Up to and including 5/8	2
11/16 to 1½ inclusive	3
Above 1½	4

Outer Cover. This is to be made of rubber of the same quality as that used for the inner tube, and of good workmanship and finish.

Dimension Limit. The internal diameter of the hose must not vary more than plus or minus 3 per cent of the given internal diameter.

Length of Hose. The manufacturer, when quoting or when acknowledging an order for this class of hose, must state the lengths in which it can be supplied. The hose should be supplied in the maximum lengths possible.

Physical Properties. By "flexibility" is meant ability to bend without kinking. When hose of internal diameter (y) is bent around a cylinder having a diameter equal to x times the external diameter of the hose, as shown in the following table, the external diameter of the hose must not increase or diminish by more than 10 per cent.

Internal Dia. (y), In.	x
Less than ½	8
½ to ¾	12
13/16 to 1⅛	14
Above 1⅛	16

The hose, after having been filled with gasoline for two hours, must withstand a minimum internal hydraulic pressure of (p) pounds per square inch, depending upon the internal diameter (d) of the hose without showing defects.

Internal Dia. (d) In.	Min. Pressure (p) lb./sq. in.
Up to ½ inclusive	160
9/16 to 1 inclusive	140
1 1/16 to 1½ inclusive	120
1 9/16 to 2 inclusive	100
Above 2	80

Chemical Properties. The rubber contents shall not be less than 25 per cent by weight of plantation or wild hevea rubber. The amount of free sulphur in either the tube, cover, or friction compound shall not exceed 1 per cent.

Dry Heat Test. A 3-in. piece of the hose after having been placed in an air oven at 132 deg. cent. for 2 hr. must show, when cool, no tendency to crack, and must not be tacky.

Permeability to Gasoline. A 142-in. length of hose is held vertically and plugged at the bottom. The upper end is fitted with a glass tube about 18 in. long. The hose so arranged is filled with gasoline* to a head of 12 in. above the top of the acting length of the hose. The acting length of the rubber hose is 12 in. The upper end of the glass tube is loosely closed with a cork.

During the first 24 hr. the level of the gasoline will fall comparatively rapidly. The loss is made good by frequent additions from a known volume of gasoline, care being taken that the level of the gasoline in the glass tube does not fall by more than 3 in. at any time. The test is to last for 72 hr., and the loss of gasoline during the third 24 hr. must not exceed 100 cc. per square foot of the original internal surface of the hose.

Immersion in Gasoline. A 3-in. piece of the hose is boiled for 1 hr. (using a reflex condenser) in gasoline similar to that used for the permeability test. The gasoline is allowed to cool down. Twenty-four hours later the test piece is removed from the gasoline and examined without delay, as follows:

The internal diameter at the point of greatest constriction is measured by means of rod gages. From this measurement the area of the bore is calculated. It must not differ from the original by more than 25 per cent.

The test-specimen is then cut longitudinally into halves, and the adhesion between rubber and cotton carefully examined. The adhesion must be of such a character that the rubber can only be stripped from the cotton by hand with difficulty.

Immersion in Oil. A 3-in. piece of the hose is immersed in oil approved by the purchaser at a temperature of 100 deg. cent. for 8 hr., and for a further period of 24 hr. at ordinary temperature. The oil is then wiped from the surface of the hose. The decrease of internal diameter shall be less than 10 per cent.

The flexibility and elasticity of the rubber must not be diminished and there must be no tendency of the rubber to separate from the cotton.

Part II. Inspection

Test-Specimens. The purchaser will decide where the tests are to be carried out. All test-specimens are to be cut in the presence of the inspector and they are to be marked as he may direct.

For the purpose of testing, a representative sample will be cut from each 1000 ft. of hose or fraction thereof, and the tests will proceed in accordance with the purchaser's instructions.

Rejections. If any sample fails to comply with any of the above tests, the hose represented thereby will be rejected.

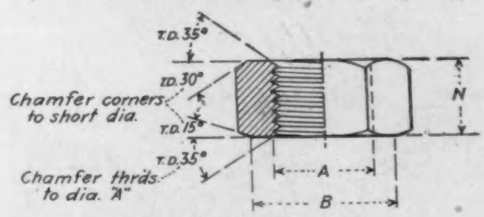
Marking. Accepted and rejected material must be marked as directed by the inspector.

Part III. Special Conditions

Depreciation. The manufacturer must bear the cost of the depreciation in value of any rejected material due to test-specimens being cut therefrom.

Rejected Material. The manufacturer must not supply any material that has previously been rejected by any Government Department, without giving full written particulars of the previous rejection to the inspector who is inspecting to this specification.

Plain Hexagon Nuts
(For Bodies and Wings, Not Engines)



T.D. = Tooling Dimensions

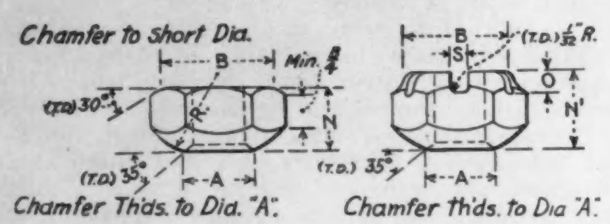
Dimensions for Plain Hexagon Nuts

Size A	Threads per In.	Hex. Short Dia. B	N
*0.1120 (No. 4)	To be determined	0.250 (1/4)	0.094 (3/32)
*0.1380 (No. 6)		0.312 (5/16)	0.109 (7/64)
0.1640 (No. 8)	32	0.375 (3/8)	0.125 (1/8)
0.1900 (No. 10)	32	0.375 (3/8)	0.141 (9/64)
0.2160 (No. 12)	32	0.438 (7/16)	0.156 (5/32)
0.2500 (1/4)	28	0.438 (7/16)	0.188 (3/16)
0.3125 (5/16)	24	0.500 (1/2)	0.234 (15/64)
0.3750 (3/8)	24	0.563 (9/16)	0.281 (9/32)
0.4375 (7/16)	20	0.688 (11/16)	0.328 (21/64)
0.5000 (1/2)	20	0.750 (3/4)	0.375 (3/8)
0.5625 (9/16)	18	0.875 (7/8)	0.422 (27/64)
0.6250 (5/8)	18	0.938 (15/16)	0.469 (15/32)

All Threads U. S. Form. *Future Sizes.

*The specific gravity of the gasoline used in this test should be between 0.710 and 0.725 at 15.5 deg. cent. (60 deg. fahr.); 65 per cent of it must distill over at 100 deg. cent. (212 deg. fahr.) from a distillation flash when the bulb of the thermometer is just below the side tube.

Ball Hexagon and Castle Nuts

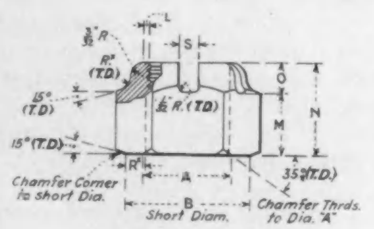


$N^1 = N + O$. T.D. = Tooling Dimensions

Bolt Size A	Thds. per Inch	Hexagon			Castle			
		B	N	R	B	N¹	S	O
0.5625 (9/16)	18	0.875 (7/8)	0.469 (15/32)	0.625	0.875 (7/8)	0.656 (21/32)	0.156	0.188 (3/16)
0.6250 (5/8)	18	0.938 (15/16)	0.516 (33/64)	0.625 (5/8)	0.938 (15/16)	0.766 (49/64)	0.156 (5/32)	0.250 (1/4)

All Threads U. S. Form. B = Also Size of Hexagon.

Castle Hexagon Nuts

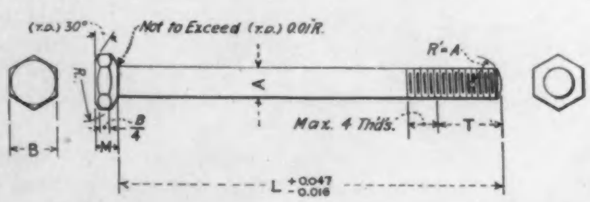


T.D. = Tooling Dimensions.

Bolt Size A	Thds. per Inch	B	N	S	O	M	L	R
0.5625 (9/16)	18	0.875 (7/8)	0.609 (39/64)	0.156	0.188 (3/16)	0.422 (27/64)	0.047	0.156
0.6250 (5/8)	18	0.938 (15/16)	0.719 (23/32)	0.156 (5/32)	0.250 (1/4)	0.469 (15/32)	0.047 (3/64)	0.156 (5/32)

All Threads U. S. Form. B = Also Size of Hexagon. O = Also Depth of Slot.

Ball Hexagon-Head Bolts



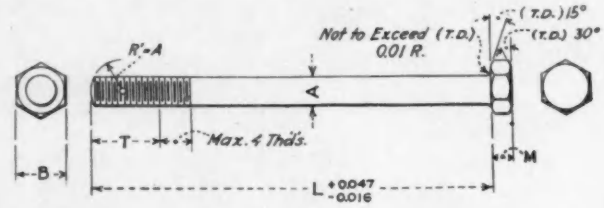
T = Min. Length of Usable Thread. T.D. = Tooling Dimensions.

Bolts Size A	Threads per Inch	A *Limits	B	M	R
0.1640 (No.8.)	32	0.164 0.160	0.313 (5/16)	0.172 (11/64)	0.375 (3/8)
0.5625 (9/16)	18	0.563 0.558	0.875 (7/8)	0.469 (15/32)	0.625 (5/8)
0.6250 (5/8)	18	0.625 0.620	0.938 (15/16)	0.516 (33/64)	0.625 (5/8)

Body length L =	1/2	5/8	3/4	7/8	1	Over 1
Length of thread T =	3/8	7/16	1/2	1/2	1/2	3/4

All threads U. S. Form. All dimensions in inches.
*Finished size, including plating or rust-preventing treatment when used. The Bureau of Standards recommend 0.001 in. as thickness of plating for rust prevention.

Plain Hexagon-Head Bolts



T = Min. Length of Usable Thread. T. D. = Tooling Dimension.

Bolts Size A	Threads per Inch	*Limits A	B	M
0.563 (9/16)	18	0.563 0.558	0.875 (7/8)	0.313 (5/16)
0.625 (5/8)	18	0.625 0.620	0.938 (15/16)	0.344 (11/32)

Body length L =	1/2	5/8	3/4	7/8	1	Over 1
Length of thread T =	3/8	7/16	1/2	1/2	1/2	3/4

All threads U. S. Form. $M = (A/2 + 1/32)$ in. All dimensions in inches.
*Finished size including plating or rust-preventing treatment when used. Bureau of Standards recommend 0.001 in. as thickness of plating for rust prevention.

Airplane Engine Testing

The following test specifications are divided into two classes, one a Routine Factory Test and the other a Type Test.

Routine Factory Test for Fixed Engines

(Low or Normal Compression)

Test No. 1. Engines may be run in by such methods as are found most satisfactory for each type of engine, but must not be run under own power over ten hours before the first official test.

Test No. 2. Engines with compression ratio of 5 or less.

Engine will be mounted on a torque stand or stationary stand and fitted with club or propeller, properly calibrated for rated load at rated speed. Engine will be fitted with all the accessories that are to be supplied by the engine manufacturer. If started by hand, it must in every attempt be started within 5 min. by one man.

Test will consist of four hours' continuous running at rated power and rated speed. All readings required shall be recorded on S. A. E. standard log sheet every ten minutes.

(a) The test must be continuous and in case of a stop occurring during the first hour, the run will be repeated.

(b) In case of a stop occurring after the first hour and not due to a fault of the engine, the run will be continued, but the inspector may require an extension of the running time equal to twice the time lost.

When a stop occurs at any time due to a fault of the engine, the inspector may require the complete run to be repeated.

(c) No manipulation of the engine, while running, will be allowed, except such as can be made by a pilot from his seat. Replenishing of gasoline and oil supplies and regulating of the cooling water temperature is allowable.

Engine will be dis-assembled, inspected, and if all parts are accepted, it will be re-assembled. If in the opinion of the inspector, parts must be replaced, he may require the whole or portion of the run to be repeated.

Test No. 3. Engine with all the accessories that are to be supplied by the manufacturer will be mounted on

a torque stand and fitted with a club or propeller, properly calibrated. It will be given a continuous run of one hour at not less than rated power and rated speed. All readings required will be recorded on S. A. E. standard log sheet every ten minutes.

After this test the engine shall be cleaned and inspected and put into condition for shipment. If satisfactory, the engine shall be stamped by the inspector.

Note—If desired, the horsepower may be corrected for air temperature and barometric pressure. In such cases the power will be corrected to a surrounding air temperature of 59 deg. fahr. (15 deg. cent.) and normal sea level pressure which is 29.92 (760 mm.) of mercury at 32 deg. fahr. (0 deg. cent.) and at 45 deg. latitude. In case of question the corrected power shall govern.

(High Compression)

Test No. 2A. Engines with compression ratio of 5 or more.

Engine will be prepared as under Test No. 1 and No. 2. This test will consist of four hours' continuous running at 8/10 rated load and rated speed. Otherwise, this test will be the same as No. 2 and the same rules will apply.

Dis-assembly and inspection will be the same as in Tests No. 2 and No. 3.

Test No. 3A. This will be the same as No. 3 but at 8/10 rated load and at rated speed.

After this test, the engine will be inspected and accepted as in Routine Test No. 3.

Airplane Engine Testing Form

Name and Model............ Date of Test...........
Manufacturer ....
(All dimensions to be given in inches.)
(1) General Type.................. Cycle........
(2) No. of Cycle....... Bore....... Stroke.......
Piston Displ. per Cyl.....cu. in. Total.....cu. in.
(3) Compression Vol. (Vc)....................cu. in.
Total Vol. of Cyl. (V)....................cu. in.
Compression Ratio = (Vc ÷ V)....Compression Pressure ....lb. At............r.p.m.
(4) Type of Cyl.............. Mat'l...............
(5) Type of Valves........... Location..........
(6) Cooling System......... Type of Pump........
Capacity.......lb. per min. at.......eng. r.p.m.
Weight of Water in Cyl. Jackets.............lb.
Water Space bet. Jacket and Cyl., Top.. Bottom..
(7) Piston, Type........... Mat'l..............
Weight without Pin and Rings....... With Pin and Rings...........
Distance from center of Pin to top of Piston.....
Length, over all.. Clearance Main Body.. Top..
Length Piston Clearance at Head..............
Length Relieved Portion at Center if any........
(8) Piston Rings, No. per Piston.. Type.. Width...
(9) Connecting-Rod Type......... Mat'l..........
Length, c. to c....... Weight, Upper end.......
Lower end.............. Total..............
No. Bolts, Lower End........ Dia. Bolts.......
Mat'l...... Weight complete with Bearing......
(10) Piston-Pin Bearings, dia... Length... Mat'l...
Location........... Method of fastening Pin in Rod or Piston........ Weight of Pin........
(11) Connecting-Rod Bearing, dia.. Length.. Mat'l..
Type.... Weight.... Method of Adjustment....
Method of Holding Bearing in Rod.............
(12) Crankshaft, Type.......... Weight..........
No. of Bearings.. Dia. Main.. Length of Front..
Length, Intermediate...... Length, Rear......
Method of Adjusting Bearings.................
No. of Bolts each Bearing... How held in Case...
Dia. Hole in Main Bearings.... In Crankpins....
Dia. Hole in Crankpins........ Dia. Hole, Main Bearings............
Cheek Thickness next to Propeller End..........
Cheek Thickness of Balance of Crank...........
Dia. of Shaft through Radial Bearing...........
No. of Radial Bearings.......... No. of Thrust Bearings............
Type of Thrust Bearing.. If Direct, what Type..
Propeller Mounting.. Length of Taper.. Dia...
Method of Holding Propeller Hub.............
No. of Hubs...... If Geared, how is Gear held to Shaft...................
If Taper, give Length........in. Dia........in.
Is Radial used in addition to Plain Bearing......
(13) Camshaft Bearings, No........ Dia........in.
Material............. Lengths.............in.
(14) Type of Cams..... Type of Valve-Lifters......
(15) Inlet Valves, No. per Cyl......o.d......in. Port dia...........in.
Lift............in. Seat Angle............deg.
(16) Exhaust Valves, No. per cyl.... o.d.....in. Port dia....in. Lift....in. Seat angle....deg.
(17) Weight of Valve Reciprocating Parts, Inlet....lb. Exhaust........lb.
(18) Valve-Spring Tension, Inlet open......lb. Closed ....lb.
Exhaust open..........lb. Closed..........lb.
*(19) Valve-Timing, Inlet opens............deg. before (after) Top Center
Closes..................deg. after Lower Center
Exhaust opens.........deg. before Lower Center
*Closes............deg. before (after) Top Center
(20) Geared Drive, Pitch...... No. Teeth Crankshaft Gear..........
No. Teeth Propeller Gear.... Width of Face....
Type Gear.............. Mat'l..............
(21) Propeller-Shaft, Type Thrust Bearing...........
No..... Radial Bearing, Front..... Rear.....
Type of Propeller-Hub Mounting...No. of Hub...

Carburetion

(22) Carbureter, Name.......... Model...........
(23) Specification (size of nozzles, etc.).............
(24) How Heated...................................
(25) General Principles of Operation...............
(26) Description of Intake Pipe...................

Ignition

(27) Name........ System........ Type........
(28) Type of Distributor...... Firing Order.......
(29) Type of Breaker...............................
Maximum Spark-Advance...deg. Retard....deg.
(30) Spark-Plugs, Name.......... Type..........
No............ Size............

Lubrication

(32) Type............ Description..............
Pressure used..................................
(33) Main Bearing Hub............................
(34) Crankpin.....................................
(35) Cylinder.....................................
(36) Method of Oil Cooling........................
(37) Oil Container........... Capacity...........
(38) Pump................ Type...............
(39) Oil used......................................

Type Tests for Fixed Engines

(Low or Normal Compression)

The first engine of a type and one out of each hundred in production will be tested under the following conditions:

The selection of the engine shall be made by the inspector without previous notice to the manufacturer.

The engine must not run under its own power over ten hours before the first official test and must be taken from regular production. (See Routine Test No. 1.)

Test No. 4. Engines with compression ratio of 5 or less.

The engine is to be mounted and equipped as in Routine Test No. 2 and fitted with a club or propeller properly calibrated.

Engine Weight Specifications

Manufacturer..

Model..

Bore......in........mm. Stroke......in........mm.

No. of cyl.................. Type..................

Piston displacement............cu. in............liters

Compression ratio...............

Horsepower..........at..........r.p.m. Computed at standard barometric pressure 29.92 in. (76 mm.), 32 deg. fahr. (0 deg. cent.), 45-deg. latitude at sea level.

Gasoline consumption....lb....kilo. per hr. at above hp.

Oil consumption.........lb....kilo. per hr. at above hp.

Propeller speed............r.p.m. at above engine speed

Weight of engine—dry..........lb...............kilo.

The weight of the engine includes the following:

1. Ignition: Service magneto. Wire and wire supports. (or) Battery ignition distributor and coils, wire and wire supports. Spark-plugs.

2. Generator (if used) attached. With cut-out and ammeter.

6. Carbureters. 7. Inlet Pipes.

Note.—Numbers refer to parts given in following schedule: Comparison of standard water-cooled engines, with rotary and fixed air-cooled types, may be made by means of schedule of weights. Give all weights in the following schedule in the proper column, and give names and weights of any other necessary parts not listed.

Mark X if Not Used	Equipment	Manufactured by	Weights: Included in Above Engine Wt. Lb.	Included in Above Engine Wt. Kilo.	Not Included in Above Engine Wt. Lb.	Not Included in Above Engine Wt. Kilo.
	1. Ignition					
	a–Service magneto (No. required.....), with attaching bolts or clamps, and complete drive					
	Wire and wire supports					
	Switch					
	b–Starting magneto, with attaching bolts or clamps, and complete drive					
	Wire and wire supports					
	Switch					
	c–Battery ignition distributor (No. required......), with bolts or clamps and complete drive					
	Coil (No. required,.....)					
	Wire with wire supports					
	Switch					
	d–Battery					
	(Capacity.....amp. hr.)					
	(Voltage..............)					
	Box, hold-down clamp and cover					
	e–Spark-plugs (No. required ....)					
	2. Generator					
	(Type of regulation.....)					
	a–Complete with cut-out, regulator, drive, bolts or clamps					
	Is ignition distributor included?					
	b–Ammeter (or voltmeter)					
	3. Electric Starter					
	a–Motor with gearshift drive, mounting brackets, strap, bolts and terminals (starting wire on body)					
	b–Starting battery					
	Cap...............amp. (hr.)					
	(Voltage..........)					
	Terminals					
	Switch					
	Box and hold-down clamps					
	4. Compressed Air Starter					
	a–Starter and compressor complete with gearshift, drive, and all piping except between starter and tank					
	b–Air storage tank with straps					
	c–Control valve					
	d–Pipe couplings (piping on body)					
	5. Hand-Starting Cranks Including attaching bolts and nuts					

Mark X if Not Used	Equipment	Manufactured by	Weights: Included in Above Engine Wt. Lb.	Included in Above Engine Wt. Kilo.	Not Included in Above Engine Wt. Lb.	Not Included in Above Engine Wt. Kilo.
	6. Carbureters (No. required.........), with attaching bolts and nuts					
	7. Inlet Pipes With bolts and nuts					
	8. Hot-Air Pipes or Stoves					
	9. Exhaust Pipes With flanges and attaching bolts and nuts					
	10. Mufflers (No. required........)					
	11. Propeller-Hub Complete with bolts and nuts					
	12. Gasoline Air-Pressure Pump With drive, bolts and nuts (piping on body)					
	13. Gasoline Pump With drive-bolts and nuts (piping on body)					
	14. Tachometer Gear Drive on Engine					
	15. Machine Gun Timing Mechanism					
	16. Water Radiator (No. required..........)					
	a-Water radiator connections to engine manifolds					
	17. Oil Radiator or Tank With connections					
	18. Oil Capacity of Crankcase					
	19. Water Capacity of Jackets, Pumps and Manifolds					
	20. Water Capacity of Radiators					
	21					
	22					
	23					
	24					
	25					

Total running time shall be fifty hours divided as follows:

Five hours at 9/10 rated power and at rated speed.

(Not over one hour's stop with minor adjustments allowed.)

Five hours at 9/10 rated power and at rated speed.

(Not over 13 hours' stop during which engine may be dis-assembled, overhauled, carbon removed, valves ground and adjusted, magnetoes and spark-plugs cleaned and adjusted. No adjustment or replacement of major parts is allowed. Any multiple part, such as a valve, may be replaced when replacement is made necessary through defective material. In no case, however, shall more than one such part be replaced during the entire fifty hours.)

Five hours at 9/10 rated power and at rated speed.

(Not over one hour's stop with minor adjustments allowed.)

Five hours at 9/10 rated power and at rated speed.

(Not over 13 hours' stop and same work allowed as before.)

Five hours at 9/10 rated power and at rated speed.

(Not over one hour stop with minor adjustments allowed.)

Five hours at rated speed and at rated power.

(Not over 13 hours' stop and same work allowed.)

Five hours at rated speed and at rated power.

(Not over one hour's stop with minor adjustments.)

Five hours at rated speed and at rated power.

(Not over 13 hours' stop and same work allowed.)

Ten hours at rated power and at rated speed.

Rule (c) under Routine Test No. 2 will apply to each run. In case of a forced stop during any of above runs, rules (a) and (b) under Routine Test No. 2 will apply.

If the stop is due to a failure of any multiple part such as a valve, the part may be replaced, providing such failure is due to defective material and a similar part has not previously been replaced since the 50-hr. test was started.

During complete run all required readings must be recorded on S. A. E. standard log sheet every ten minutes. The mean power (see note under Routine Test No. 3) must not fall below the rated power; and gasoline and oil consumption must not exceed the predetermined maximum.

After the test is completed, the engine is to be dissembled and if acceptable to the inspector, may be re-assembled after replacing any parts that the inspector may designate.

Test No. 5. The engine is to be mounted in a body (fuselage) or tilting stand and fitted with propeller. With the axis of the engine making 15 deg. with horizontal, it is to run at full power full speed for fifteen minutes. Then without altering speed or any part, or adjustment, the axis is to be brought again horizontal and then tilted to 15 deg. in the opposite direction and run fifteen minutes.

If this test is satisfactory, the engine wlil be put through Routine Test No. 3 except that the running time shall be thirty minutes instead of one hour. After this test, the engine will be inspected and accepted as in Routine Test No. 3.

(High Compression)

Test No. 4A. Engines with compression ratio of 5 or more.

This test will be the same as test No. 4 but the first five runs shall be made at 7/10 rated load and at rated speed. The next four runs will be made at 8/10 rated load and at rated speed.

Dis-assembly and inspection will be the same as in Tests No. 4 and No. 5.

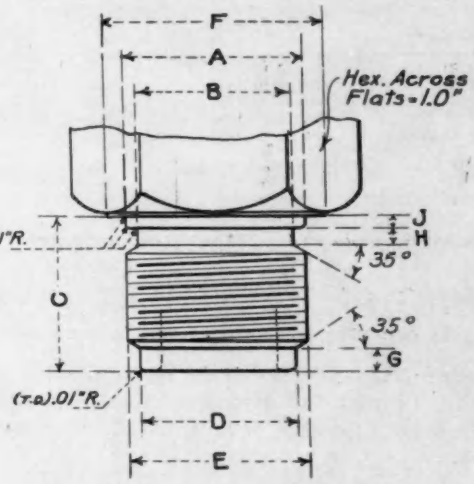
Test 5A. Engine will be put through a test the same as No. 5 but at 8/10 rated load and at rated speed.

If the engine passes Test 5A it will be put through Routine Test No. 3A except that the running time will be thirty minutes instead of one hour. This engine will then be inspected and accepted as in Routine Test No. 3.

Spark-Plug Shell Dimensions

The thread is to be 18 mm. with 1½ mm. pitch.

The form of thread should be the International standard (same as U. S. standard, except that truncation is one-half as much at root of thread).



Spark-Plug Shell Dimensions

Dimension	Maximum		Minimum	
	Mm.	In.	Mm.	In.
A	18.03	0.710	17.93	0.706
B	16.87	0.664	15.87	0.625
C	15.87	0.625 (5/8)	15.87	0.625 (5/8)
D	15.87	0.625	......	......
E	17.97	0.708	17.85	0.703
F	......	......	23.83	0.938 (15/16)
G	......	......	2.38	0.094 (3/32)
H	1.98	0.078 (5/64)	......	......
J	1.19	0.047 (3/64)	......	......

Spark-Plug Thread Dimensions

Diameter	Maximum		Minimum	
	Mm.	In.	Mm.	In.
Outside	17.975	0.70768 (0.708)	17.850	0.70275 (0.703)
Pitch	17.001	0.66933 (0.669)	16.876	0.66441 (0.664)
Root	15.864	0.62457 (0.625)	15.739	0.61964 (0.620)

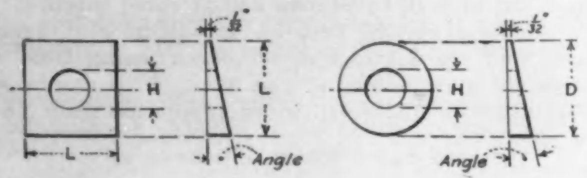
Tapped Hole Dimensions

Diameter	Maximum		Minimum	
	Mm.	In.	Mm.	In.
Outside	18.325	0.72146 (0.721)	18.187	0.71603 (0.716)
Pitch	17.176	0.67622 (0.676)	17.051	0.67124 (0.671)
Root	16.201	0.63783 (0.638)	16.076	0.63291 (0.633)

The limits for spark-plug threads as shown in the accompanying table have been reported as adopted by the (British) Engineering Standards Committee.

The standard thread for spark-plug terminal is No. 8-32 (0.164 dia.), A. S. M. E. standard.

BEVEL WASHERS



DIMENSIONS OF SQUARE AND ROUND BEVEL WASHERS

Bolt Size*	*H*	*D*	*L*
No. 4 (0.112)	No. 31 (0.120)	3/8	3/8
No. 6 (0.138)	No. 26 (0.147)	7/16	3/8
No. 8 (0.164)	No. 17 (0.173)	15/32	15/32
No. 10 (0.190)	No. 8 (0.199)	1/2	15/32
No. 12 (0.216)	No. 1 (0.228)	9/16	17/32
1/4	17/64	5/8	17/32
5/16	21/64	11/16	21/32
3/8	25/64	3/4	21/32
7/16	29/64	15/16	7/8
1/2	33/64	1	7/8

*The values of the angles are 6, 12, 24 and 36 deg. for all sizes.

REPORT OF DATA-SHEET DIVISION

(*As accepted for submission to mail vote*)

Cancelled Data Sheets. It is recommended that Data Sheets 6g (Finish of Hexagon Cap Screws) and 51 (French Road Signals), Vol. I, S. A. E. Handbook, be cancelled.

Changes in Nomenclature. (a) It is recommended that on Data Sheet 8b, Vol. I, the heading "Industrial Truck Wheels" be changed to be "Industrial Truck Tires," and that the heading "Wheel Dimensions" in the first column of the table be changed to "Tire Dimensions." (b) It is recommended that wherever the expression "pleasure car" occurs in the Data Sheets the expression "passenger car" be substituted.

REPORT OF LIGHTING DIVISION

(*As accepted for submission to mail vote*)

Head-Lamp Illumination. It is recommended that head-lamps shall be so arranged that no portion of the direct reflected beam cone of light, when measured 75 ft. ahead of the head-lamps, shall rise above 42 in. from the level surface of the road on which the vehicle stands, under any condition of loading; nor shall any portion of the direct-reflected beam cone of light rise, beyond the 75-ft. distance, more than 12 in. above the center of the head-lamp.

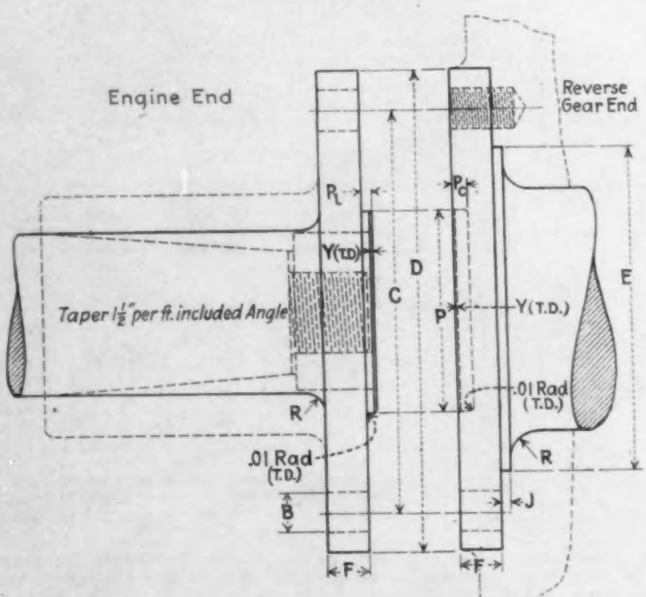
To avoid a rise in the beam cone of light to an objectionable height beyond the 75-ft. distance, particularly in cases where head-lamps are set relatively low on the car, the Division recommend that the word "at" be changed to "beyond" in the previously accepted recommendation. The direct and reflected rays (other than those direct-reflected rays from the parabolic reflector, which constitute the beam cone) are of such relatively small value that they have little influence.

Head-Lamp Bulbs. The Division has previously recommended that the focal length of electric incandescent lamps for automobiles be 1¼ in. In view of this and the fact that the G-16½ bulb is used ordinarily in electric vehicles, the 1¼-in. focal length is now recommended in the electric incandescent lamps for both gas and electric vehicle head-lamps.

REPORT OF MARINE DIVISION

(*As accepted for submission to mail vote*)

FLANGE STEEL COUPLING
(Engine and Reverse Gear)



ENGINE COUPLING
(STEEL)

TABLE I—FLANGE STEEL COUPLING (ENGINE AND REVERSE GEAR)

Size No.	Flange					Pilot				Bolts			
	D	*E*	*F*	*J*	*R*	*Pe*	*Pe*	*Pe*	*Y*	No.	*B*†	Thds. per Inch	*C*
4	4	2 13/32	3/8	1/8	3/16	1 5/8	1/16	1/8	1/64	4	3/8	24	3
5	5	3 11/32	7/16	3/16	3/16	2	1/8	3/16	1/32	6	7/16	20	4
6	6	4 1/16	1/2	1/4	1/4	2 1/2	1/8	3/16	1/32	6	7/16	18	5
7	7	4 1/2	5/8	5/16	5/16	3	3/16	1/4	1/32	6	5/8	18	5 1/2
8	8	5 3/8	3/4	3/8	3/8	3 3/4	3/16	1/4	1/32	6	3/4	16	6 1/2
9	9	6 1/16	7/8	3/8	7/16	4 3/8	1/4	5/16	3/64	6	7/8	14	7 3/8
10	10	6 1/2	1	1/2	1/2	5	5/16	3/8	3/64	6	1	14	8

*Pilot tolerance +.000, −.001 in. per inch of diameter. Pilot-recesstolerance, +.001, −.000 in. per inch of diameter.
†Figures in column indicate bolt diameters. Use clearance drill of same nominal size for holes *B* in flange.
(T. D.) = Tooling dimensions.

In the accompanying drawing the engine flange when integral with the engine shaft is shown in full lines. When separate, the shaft taper and dimensions are the same as for reverse gear coupling of the corresponding size shown in Table II.

The reverse gear flange shown by full lines shall have drilled bolt holes. When the flange is designed integral with the reverse gear, as shown by dotted lines, the bolt holes shall be drilled and tapped for S. A. E. standard cap screws. All bolts shall have S. A. E. standard

threads, as shown on Data Sheet 4, Vol. I, S. A. E. Handbook.

These couplings are designed to be made of steel and are intended for high power engines.

FLANGE STEEL COUPLING

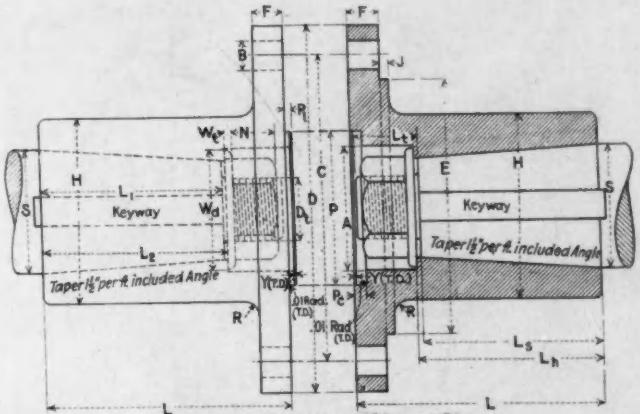
(Reverse Gear and Propeller Shaft)

All bolts shall have S. A. E. standard threads as shown on Data Sheet 4, Vol. I, S. A. E. Handbook. (Safety sleeves or covers for these couplings are being considered by the Marine Division.)

CLAMP STEEL COUPLING

(Propeller-shaft extension)

The clamp coupling shown in the accompanying drawing is for propeller-shaft extension and is not intended for coupling propeller shaft directly to the reverse gear.



STEEL REVERSE COUPLNG

TABLE II—DIMENSIONS OF FLANGE STEEL COUPLING (REVERSE GEAR AND PROPELLER-SHAFT)

Size No.	Shaft				Keyway		Nut‡		Washer		Flange					Pilot				Hub				Bolts		
	S	Ls	Dt	Lt	Width	Height	N	Thds. S.A.E.	Wt	Wd	D	E	F	J	A	P*	Pl	Pc	Y	H	L	Lh	R	No.	B†	C
RPS 8	1	1 13/16	9/16	5/8	1/4	1/8	7/16	18	1 3/16	1/8	4	2 13/32	5/8	1/16	1 3/8	1 3/8	1/16	1/8	1/64	1 3/8	2 1/2	1 7/8	3/16	4	3/8	3
RPS 9	1 1/8	1 13/16	9/16	5/8	1/4	1/8	7/16	18	1 3/16	1/8	4	2 13/32	5/8	1/16	1 3/8	1 3/8	1/16	1/8	1/64	1 3/8	2 1/2	1 7/8	3/16	4	3/8	3
RPS 10	1 1/4	2 3/16	3/4	3/4	5/16	5/32	9/16	16	1 7/16	1/8	5	3 11/32	7/16	3/32	1 3/8	2	1/8	3/16	1/32	2 3/8	3	2 1/4	7/32	6	7/16	4
RPS 11	1 3/8	2 3/16	3/4	3/4	3/8	3/16	9/16	16	1 7/16	1/8	5	3 11/32	7/16	3/32	1 3/8	2	1/8	3/16	1/32	2 3/8	3	2 1/4	7/32	6	7/16	4
RPS 12	1 1/2	2 3/16	3/4	3/4	3/8	3/16	9/16	16	1 7/16	1/8	5	3 11/32	7/16	3/32	1 3/4	2	1/8	3/16	1/32	2 3/8	3	2 1/4	7/32	6	7/16	4
RPS 13	1 5/8	2 3/16	3/4	3/4	3/8	3/16	9/16	16	1 7/16	1/8	5	3 11/32	7/16	3/32	1 3/4	2	1/8	3/16	1/32	2 3/8	3	2 1/4	7/32	6	7/16	4
RPS 14	1 3/4	2 15/16	1	1	7/16	7/32	3/4	14	1 15/16	1/8	6	4 1/16	1/2	1/8	2 3/16	2 1/2	1/8	3/16	1/32	3	4	3	1/4	6	9/16	5
RPS 15	1 7/8	2 15/16	1	1	1/2	1/4	3/4	14	1 15/16	1/8	6	4 1/16	1/2	1/8	2 3/16	2 1/2	1/8	3/16	1/32	3	4	3	1/4	6	9/16	5
RPS 16	2	2 15/16	1	1	1/2	1/4	3/4	14	1 15/16	1/8	6	4 1/16	1/2	1/8	2 3/16	2 1/2	1/8	3/16	1/32	3	4	3	1/4	6	9/16	5
RPS 18	2 1/4	3 13/16	1 1/8	1 1/8	9/16	9/32	1 1/16	12	2 7/16	3/16	7	4 1/2	5/8	1/8	2 1/2	3	3/16	1/4	1/32	3 3/4	5	3 7/8	5/16	6	5/8	5 1/2
RPS 20	2 1/2	3 13/16	1 1/8	1 1/8	5/8	5/16	1 3/16	12	2 7/16	3/16	7	4 1/2	5/8	1/8	2 1/2	3	3/16	1/4	1/32	3 3/4	5	3 7/8	5/16	6	5/8	5 1/2
RPS 22	2 3/4	4 1/8	1 3/8	1 1/4	3/4	3/8	7/8	12	2 15/16	1/4	8	5 3/8	3/4	1/8	3	3 3/4	1/4	5/16	3/64	4 3/8	5 1/2	4 1/4	3/8	6	3/4	6 1/2
RPS 24	3	4 5/8	1 3/8	1 1/4	3/4	3/8	7/8	12	2 15/16	1/4	8	5 3/8	3/4	1/8	3	3 3/4	1/4	5/16	3/64	4 3/8	6	4 3/4	3/8	6	3/4	6 1/2
RPS 26	3 1/4	5 7/16	1 1/2	1 3/8	7/8	7/16	7/8	12	3 7/16	1/4	9	6 1/16	7/8	3/16	3 3/4	4 3/8	1/4	5/16	3/64	5	7	5 3/8	7/16	6	7/8	7 3/8
RPS 28	3 1/2	5 7/16	1 3/4	1 3/8	15/16	15/32	7/8	12	3 7/16	1/4	9	6 1/16	7/8	3/16	3 3/4	4 3/8	1/4	5/16	3/64	5	7	5 3/8	7/16	6	7/8	7 3/8
RPS 32	4	6 1/4	2	1 1/2	1	1/2	1 5/16	12	3 15/16	5/16	10	6 1/2	1	3/16	4 1/4	5	5/16	3/8	3/64	6	8	6 1/2	1/2	6	1	8

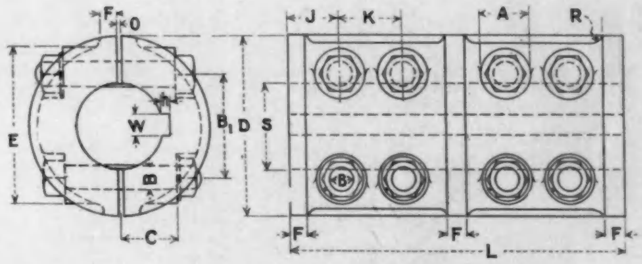
*Pilot tolerance, +0.000, −0.001 in. per inch of diameter. Pilot-recess tolerance, +0.001, −0.000 in. per inch of diameter.
†Figures in column indicate bolt diameters. Use clearance drill of same nominal size for holes *B* in flange.
‡Nuts for Style Nos. RPC 26 and RPC 28 use 2¾ in. hex stock.
Nuts for Style No. RPC 32 use 3 in. hex stock.
(T. D.) =Tooling dimensions.

Unless otherwise specified S. A. E. manganese bronze No. 29 should be used. All bolts shall have S. A. E. standard threads as shown on Data Sheet 4, Vol. I, S. A. E. Handbook. (Safety sleeves or covers for these couplings are being considered by the Division.)

FLANGE CAST IRON COUPLING

(Reverse Gear and Propeller Shaft)

The couplings shown in the accompanying drawings are for low power engines and may be made from a good grade of cast iron.

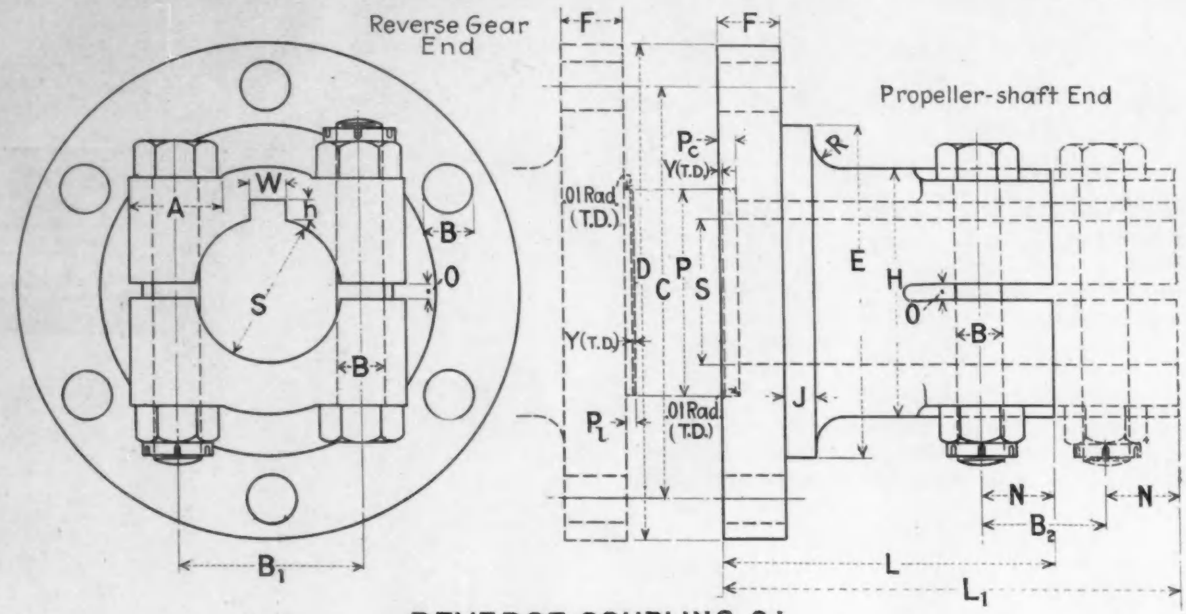


SHAFT COUPLING

TABLE III—DIMENSIONS OF CLAMP BRONZE COUPLINGS (PROPELLER-SHAFT EXTENSION)

Size No.	S	Keyway		Clamp								Bolts				
		W	h	L	D	E	F	A	C	R	O	No.	B*	B_1	J	K
PS 8	1	1/4	1/8	5	2 3/4	2	1/4	7/8	3/4	1/8	1/8	8	3/8	1 11/32	13/16	1
PS 9	1 1/8	1/4	1/8	5	2 3/4	2	1/4	7/8	3/4	1/8	1/8	8	7/16	1 15/32	13/16	1
PS 10	1 1/4	5/16	5/32	6	3	2 1/8	5/16	15/16	13/16	5/32	1/8	8	7/16	1 9/16	15/16	1 3/16
PS 11	1 3/8	3/8	3/16	6	3	2 1/8	5/16	15/16	7/8	5/32	1/8	8	7/16	1 11/16	15/16	1 3/16
PS 12	1 1/2	3/8	3/16	6	3 3/8	2 1/2	5/16	1 3/16	7/8	5/32	1/8	8	1/2	1 7/8	15/16	1 1/4
PS 13	1 5/8	7/16	7/32	7	3 1/2	2 3/4	7/16	1 3/16	1	7/32	1/8	8	1/2	2	1 1/8	1 1/2
PS 14	1 3/4	7/16	7/32	7	4	2 7/8	7/16	1 3/16	1 1/16	7/32	1/8	8	9/16	2 3/16	1 1/8	1 1/2
PS 15	1 7/8	1/2	1/4	8	4	3 1/8	7/16	1 5/16	1 1/8	7/32	1/8	8	5/8	2 3/8	1 5/16	1 5/8
PS 16	2	1/2	1/4	8	4 3/8	3 3/8	7/16	1 5/16	1 3/16	7/32	1/8	8	5/8	2 1/2	1 5/16	1 5/8
PS 18	2 1/4	9/16	9/32	9	5 1/4	3 7/8	9/16	1 1/2	1 5/16	9/32	1/8	8	3/4	2 13/16	1 7/16	1 7/8
PS 20	2 1/2	5/8	5/16	10	5 1/2	4 1/4	5/8	1 1/2	1 7/16	5/16	1/8	8	3/4	3 1/16	1 9/16	2 1/8
PS 22	2 3/4	3/4	3/8	11	6	4 5/8	11/16	1 3/4	1 9/16	3/8	1/8	8	7/8	3 3/8	1 3/4	2 5/16
PS 24	3	3/4	3/8	12	6 1/4	5	3/4	1 3/4	1 11/16	3/8	3/16	8	7/8	3 5/8	1 15/16	2 1/2
PS 26	3 1/4	7/8	7/16	12 1/2	6 3/4	5 3/4	13/16	1 3/4	2 1/2	7/16	3/16	8	7/8	3 7/8	2 1/16	2 9/16
PS 28	3 1/2	15/16	15/32	14	7	6	7/8	2	2 5/8	7/16	3/16	8	1	4 1/4	2 1/4	3 11/16
PS 32	4	1	1/2	18	8 1/4	6 3/4	7/8	2	2 7/8	1/2	1/4	12	1	4 3/4	2 3/8	2 7/8

*Figures in column indicate bolt diameters. Use clearance drill of same nominal size for holes *B* in flange.



REVERSE COUPLING C.I.
(For Low HP)

TABLE IV—DIMENSIONS OF FLANGE CAST IRON COUPLINGS (REVERSE GEAR AND PROPELLER-SHAFT)

Size No.	h	Keyway		Flange				Pilot				Hub									Bolts, S. A. E.			
		W	h	D	H	F	J	P*	P_1	Pc	Y	H	L	L_1	N	B_1	B_2	R	O	A	No.	B†	Threads per Inch	C
RPC 6	3/4	3/16	3/32	4	2 13/32	1/2	1/4	1 5/8	1/16	1/8	1/64	2	2	...	5/8	1 1/16	...	1/4	1/8	3/4	4	3/8	24	3
RPC 7	7/8	3/16	3/32	4	2 13/32	1/2	1/4	1 5/8	1/16	1/8	1/64	2	2	...	5/8	1 3/16	...	1/4	1/8	3/4	4	3/8	24	3
RPC 8	1	1/4	1/8	4	2 13/32	1/2	1/4	1 5/8	1/16	1/8	1/64	2	2	...	5/8	1 9/32	...	1/4	1/8	3/4	4	3/8	24	3
RPC 9	1 1/8	1/4	1/8	5	3 11/32	5/8	5/16	2	1/8	3/16	1/32	2 1/2	2 1/2	...	3/4	1 15/32	...	5/16	5/32	7/8	6	7/16	20	4
RPC 10	1 1/4	5/16	5/32	5	3 11/32	5/8	5/16	2	1/8	3/16	1/32	2 1/2	2 1/2	...	3/4	1 9/16	...	5/16	5/32	7/8	6	7/16	20	4
RPC 11	1 3/8	3/8	3/16	5	3 11/32	5/8	5/16	2	1/8	3/16	1/32	2 1/2	2 1/2	...	3/4	1 11/16	...	5/16	5/32	7/8	6	7/16	20	4
RPC 12	1 1/2	3/8	3/16	6	4 1/16	3/4	3/8	2 1/2	1/8	3/16	1/32	3	...	4	7/8	1 15/16	1 1/2	3/8	3/16	1 1/8	6	9/16	18	5
RPC 13	1 5/8	7/16	7/32	6	4 1/16	3/4	3/8	2 1/2	1/8	3/16	1/32	3	...	4	7/8	2 1/16	1 1/2	3/8	3/16	1 1/8	6	9/16	18	5
RPC 14	1 3/4	7/16	7/32	6	4 1/16	3/4	3/8	2 1/2	1/8	3/16	1/32	3	...	4	7/8	2 3/16	1 1/2	3/8	3/16	1 1/8	6	9/16	18	5
RPC 15	1 7/8	1/2	1/4	7	4 1/2	15/16	7/16	3	3/16	1/4	1/32	4	...	5	1	2 3/8	2	7/16	3/16	1 1/4	6	5/8	18	5 1/2
RPC 16	2	1/2	1/4	7	4 1/2	15/16	7/16	3	3/16	1/4	1/32	4	...	5	1	2 1/2	2	7/16	3/16	1 1/4	6	5/8	18	5 1/2
RPC 18	2 1/4	9/16	9/32	8	5 3/8	1 1/8	1/2	3 3/4	1/4	5/16	3/64	4 3/4	...	6	1 1/8	2 13/16	2 1/2	1/2	1/4	1 1/2	6	3/4	16	6 1/2
RPC 20	2 1/2	5/8	5/16	8	5 3/8	1 1/8	1/2	3 3/4	1/4	5/16	3/64	4 3/4	...	6	1 1/8	3 1/16	2 1/2	1/2	1/4	1 1/2	6	3/4	16	6 1/2
RPC 22	2 3/4	3/4	3/8	9	6 1/16	1 3/8	5/8	4 3/8	1/4	5/16	3/64	5 3/4	...	7	1 1/4	3 3/8	3	5/8	5/16	1 3/4	6	7/8	14	7 3/8
RPC 24	3	3/4	3/8	9	6 1/16	1 3/8	5/8	4 3/8	1/4	5/16	3/64	5 3/4	...	7	1 1/4	3 5/8	3	5/8	5/16	1 3/4	6	7/8	14	7 3/8

*Pilot tolerance, −0.000, −0.001 in. per inch of diameter. Pilot recess tolerance, −0.001, −0.000 in. per inch diameter.
†Figures in column indicate bolt diameters. Use clearance drill of same nominal size for holes *B* in flange.
(T. D.) = Tooling dimensions.

TABLE V—DIMENSIONS OF PROPELLER MOUNTINGS FOR MARINE PRACTICE

Size No.	Shaft							Hub				Nut			Keyway			
	S	Sl	Sd	T	Tl	Thds. U.S.S.	A	H	Hl	Hd	F	N	W	O U.S.S.	K	h	M	R
*P 6	3/4	2 1/8	0.637	1/2	1	13	3/32	1 1/2	2 1/4	0.629	1/8	1 1/2	7/8	3/16	3/16	3/32	3/32	1 29/32
*P 7	7/8	2 1/2	0.719	5/8	1	11	31/32	1 3/4	2 5/8	0.711	1/8	1 3/4	31/32	3/16	3/16	3/32	3/32	2 9/32
*P 8	1	2 7/8	0.821	5/8	1	11	3/32	2	3	0.813	3/16	2	1 1/16	3/16	1/4	1/8	1/8	2 9/16
P 9	1 1/8	3 1/4	0.922	3/4	1 1/4	10	3/32	2 1/4	3 3/8	0.914	3/16	2 1/4	1 1/4	3/16	1/4	1/8	1/8	2 15/16
P 10	1 1/4	3 5/8	1.024	3/4	1 1/4	10	3/32	2 1/2	3 3/4	1.016	3/16	2 1/2	1 7/16	3/16	5/16	5/32	5/32	3 9/32
P 11	1 3/8	4	1.125	7/8	1 1/4	9	1/8	2 3/4	4 1/8	1.117	1/4	2 3/4	1 5/8	3/16	3/8	3/16	3/16	3 9/16
P 12	1 1/2	4 3/8	1.227	1	1 1/4	8	1/8	3	4 1/2	1.219	1/4	3	1 5/8	3/16	3/8	3/16	3/16	3 15/16
P 13	1 5/8	4 3/4	1.329	1	1 1/4	8	1/8	3 1/4	4 7/8	1.321	5/16	3 1/4	1 3/4	1/4	7/16	7/32	7/32	4 7/32
P 14	1 3/4	5 1/8	1.429	1	1 1/4	8	1/8	3 1/2	5 1/4	1.422	5/16	3 1/2	2	1/4	7/16	7/32	7/32	4 19/32
P 15	1 7/8	5 1/2	1.532	1 1/8	1 3/8	7	5/32	3 3/4	5 5/8	1.524	5/16	3 3/4	2	1/4	1/2	1/4	1/4	4 15/16
P 16	2	5 7/8	1.633	1 1/8	1 3/8	7	5/32	4	6	1.625	5/16	4	2 3/16	1/4	1/2	1/4	1/4	5 7/16
P 18	2 1/4	6 5/8	1.837	1 3/8	1 5/8	6	5/32	4 1/2	6 3/4	1.829	3/8	4 1/2	2 9/16	5/16	9/16	9/32	9/32	5 31/32
P 20	2 1/2	7 3/8	2.039	1 1/2	1 7/8	6	5/32	5	7 1/2	2.031	7/16	5	2 3/4	3/8	5/8	5/16	5/16	6 5/8
P 22	2 3/4	8 1/8	2.242	1 3/4	1 7/8	5	3/16	5 1/2	8 1/4	2.234	7/16	5 1/2	3 1/8	3/8	3/4	3/8	3/8	7 5/16
P 24	3	8 7/8	2.444	2	2	4 1/2	3/16	6	9	2.436	1/2	6	3 1/2	3/8	3/4	3/8	3/8	8
P 26	3 1/4	9 5/8	2.657	2	2	4 1/2	3/16	6 1/2	9 3/4	2.641	1/2	6 1/2	3 5/8	3/8	13/16	13/32	13/32	8 23/32
†P 28	3 1/2	10 1/4	2.860	2	2 1/8	4 1/2	1/4	7	10 1/2	2.844	1/2	7	.....	.....	13/16	13/32	13/32	9 11/32
†P 32	4	11 3/4	3.266	2	2 1/8	4 1/2	5/16	8	12	3.250	1/2	8	.....	.....	7/8	7/16	7/16	10 13/16

*The 3/4, 7/8 and 1-in. shaft-nuts are cast solid and drilled hollow as shown by the dotted line.
†These sizes are for the 3 1/2 and 4-in. shafts only unless otherwise specified.

All bolts shall have S. A. E. standard threads as shown on Data Sheet 4, Vol. I, S. A. E. Handbook. (Safety sleeves or covers for these couplings are being considered by the Marine Division.)

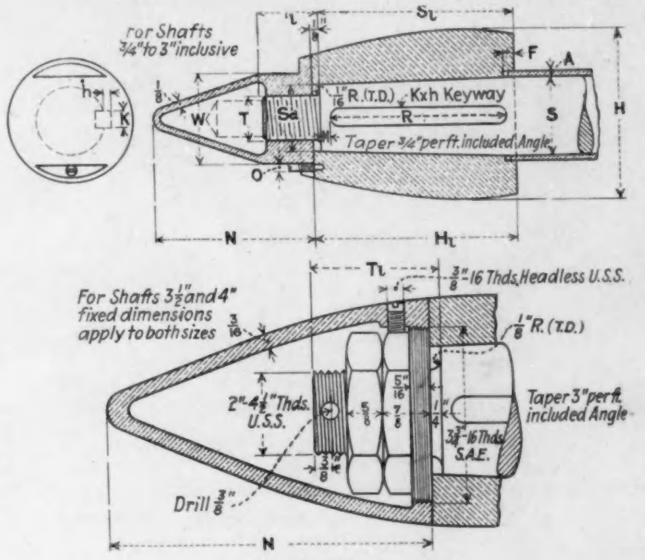
Propeller Mounting

For use in salt water, bronze or other non-corrosive metal is recommended for all parts of hub, shaft and fairwater assembly.

When bronze is used it is recommended that it have a tensile strength of 60,000 lb. per sq. in., and an elongation of 28 per cent in 2 in.

The chemical composition of a bronze conforming to these physical properties is as follows: Carbon, 62 per cent; tin, 1 per cent, and spelter, 37 per cent. A similar bronze is known by the trade name of "Tobin."

The small ends of shaft and hub tapers are the governing dimensions as shown in columns S_d and H_d. This is to insure proper fit with varying hub lengths.



PROPELLER MOUNT

REPORT OF MISCELLANEOUS DIVISION

(As accepted for submission to mail vote)

Screw Threads. The fine pitch threads for screws from 1/4 to 1 1/2 in., shown in the accompanying table, are submitted for approval as standard practice. These, taken with the threads given on Data Sheets 4 and 4c, Vol. I, S. A. E. Handbook, complete the list of S. A. E. screw standards. All these threads are to be of the U. S. form.

Table of Screw Thread Dimensions

Diameter, In.	Regular Pitch	Fine Pitch	Diameter, In.	Regular Pitch	Fine Pitch
1/4	28	36	3	10	16
5/16	24	32	3 1/8	10	16
3/8	24	32	3 1/4	10	16
7/16	20	28	3 3/8	10	16
1/2	20	28	3 1/2	10	16
9/16	18	24	3 5/8	10	16
5/8	18	24	3 3/4	10	16
11/16	16	24	3 7/8	10	16
3/4	16	20	4	10	16
7/8	14	20	4 1/8	10	16
1	14	20	4 1/4	10	16
1 1/8	12	18	4 3/8	10	16
1 1/4	12	18	4 1/2	10	16
1 3/8	12	18	4 5/8	10	16
1 1/2	12	18	4 3/4	10	16
1 5/8	12	16	4 7/8	10	16
1 3/4	12	16	5	10	16
1 7/8	12	16	5 1/8	10	16
2	12	16	5 1/4	10	16
2 1/8	12	16	5 3/8	10	16
2 1/4	12	16	5 1/2	10	16
2 3/8	12	16	5 5/8	10	16
2 1/2	12	16	5 3/4	10	16
2 5/8	12	16	5 7/8	10	16
2 3/4	12	16	6 & over	8	16
2 7/8	12	16			

Note.—The maximum screw size equals nominal or basic screw size (for all except wrench fits). In the minimum gage for internal threads and the maximum gage for external threads, the profile of the threads shall be such as not to encroach on that of the true United States Standard (or Franklin Institute) thread. These recommendations are made to insure interchangeability and do not pertain to dimensions or clearances.

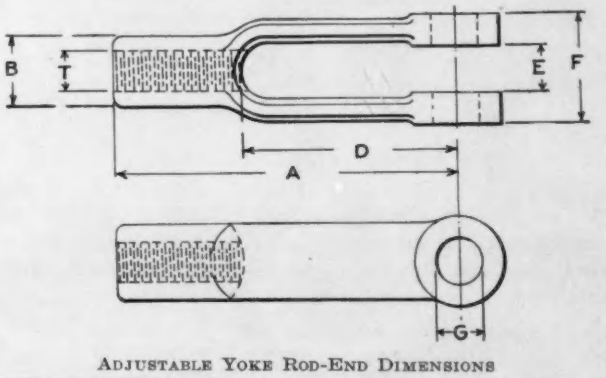
Bumpers and Mounting. After careful review of the proper height of both front and rear bumper for various conditions of loading, fender clearance and collision, the Division recommends the following table of heights and dimensions for standardization:

Bumper Heights and Dimensions

	Front	Rear
Height, center of face to ground	21	22
Overall length	Between 59 and 60	Between 59 and 60
Bumper face	Flat	Flat
Vertical depth of bumper bar (min.)	2	2 1/2

All dimensions in inches.

Yoke and Eye Rod Ends. The dimensions* for adjustable yoke rod-ends, plain yoke rod-ends and eye rod-ends, previously listed as "future sizes," are now submitted for approval as S. A. E. Standards.

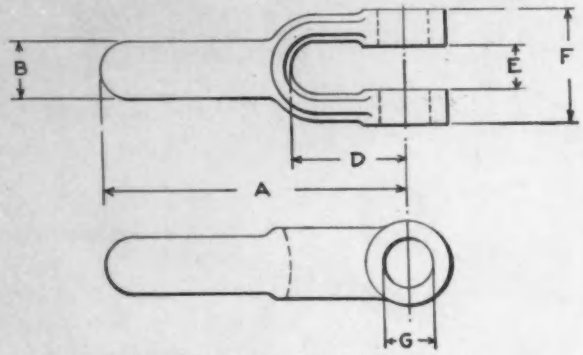


Adjustable Yoke Rod-End Dimensions

T	*A*	*B*	*D*	*E*	*F*	*G*	Limits of *G*
7/8—14	7 1/8	1 7/16	5 1/4	15/16	1 7/8	7/8	+0.001 −0.002
1—14	8	1 5/8	6	1 1/16	2 1/8	1	+0.001 −0.002

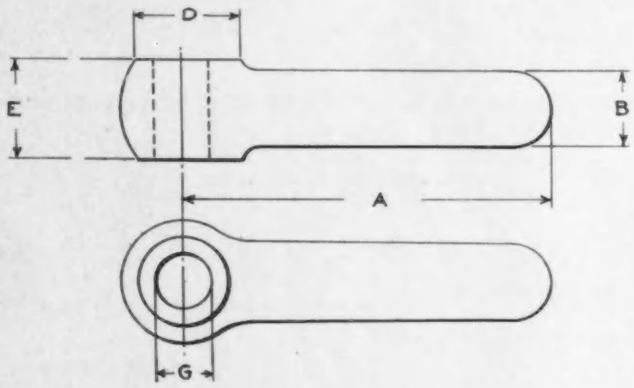
Threads U. S. Form.

*See report of Miscellaneous Division, Part I, 1917, S. A. E. Transactions and Data Sheets 1, 1a and 2, S. A. E. Handbook.



PLAIN YOKE ROD-END DIMENSIONS

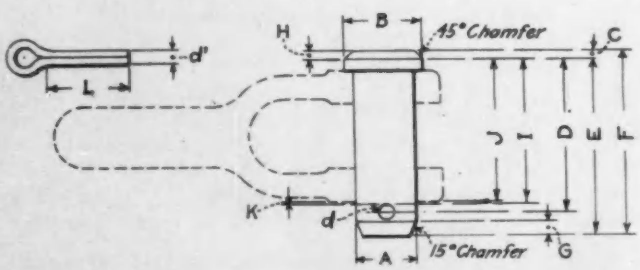
B	*A*	*D*	*E*	*F*	*G*	Limits of *G*
7/8	4	2	1 5/16	1 7/8	7/8	+0.001 −0.002
1	4 1/2	2 1/4	1 1/16	2 1/8	1	+0.001 −0.002



EYE ROD-END DIMENSIONS

A	*B*	*D*	*E*	*G*	Limits of *G*
2 3/4	7/8	1 13/16	15/16	7/8	+0.001 −0.002
3	1	1 15/16	1 1/16	1	+0.001 −0.002

Rod-End Pins. The following extension of rod-end pin dimensions* is recommended. This extension is for the pins required for the yoke and eye rod-ends, sizes 7/8 and 1 inch.



*See report of Miscellaneous Division, THE JOURNAL, July, 1917, and Data Sheet 2a, Vol. I, S. A. E. Handbook.

TABLE OF ROD-END PIN DIMENSIONS

A	Limits of *A*	*B*	*C*	*D*		E	*F*	*G*	*H*
7/8	−0.004 −0.007	1 1/16	5/16	2 1/64	2.0156	2 11/32	2 21/32	3/16	3/32
1	−0.004 −0.007	1 3/16	11/32	2 17/64	2.2563	2 5/8	2 31/32	7/32	7/64

A	*I*	S. A. E. Standard Yoke *J*	*K*	COTTER PIN		*d* = DRILL		DIFFERENCE	
				d'	*L*	No.	Dia.	*d* − *d'*	**d* − *d'* + *k*
7/8	1.9201	1 7/8	0.0451	11/64	1 1/2	11	0.191	0.0191	0.0642
1	2.1701	2 1/8	0.0451	11/64	1 3/4	11	0.191	0.0191	0.0642

*Total clearance between yoke and cotter pin.

REPORT OF MOTORCYCLE DIVISION

(As accepted for submission to mail vote)

The following list of standards is recommended by the Division, to be incorporated in the Government military motorcycle specifications for all service.

Spark control on military motorcycles shall be of the handlebar-grip type placed on the left-hand side and arranged so the spark will be advanced when the top of the grip is turned toward the center.

Throttle control on military motorcycles shall be of the handlebar-grip type, placed on the right-hand side and arranged so that the throttle will be opened when the top of the grip is twisted toward the center.

Kick starters on military motorcycles shall be of the folding-pedal type, arranged so as to operate when pushed down and back.

It is believed by the Division that starters cannot be confined to a definite side until further standardization of engines takes place.

Clutch pedals on military motorcycles shall be placed on the left-hand side and shall act to release the clutch when the pedal is pushed forward and down, clutching by reverse action.

Brake pedals on military motorcycles shall be placed on the right-hand side and so that the brake will be applied when it is pushed down.

Driving Chains on military motorcycles shall be of the roller type, with 5/8-in. pitch; roller width 3/8 in.; and roller diameter, 0.40 in.

Oil and grease cups on military motorcycles shall have an attaching diameter of 5/16 inch with 32 threads.

Military motorcycles shall have an engine displacement of not less than 60 nor more than 61 cubic inches.

Gearshifts on military motorcycles shall be placed on the left-hand side and be of the progressive type.

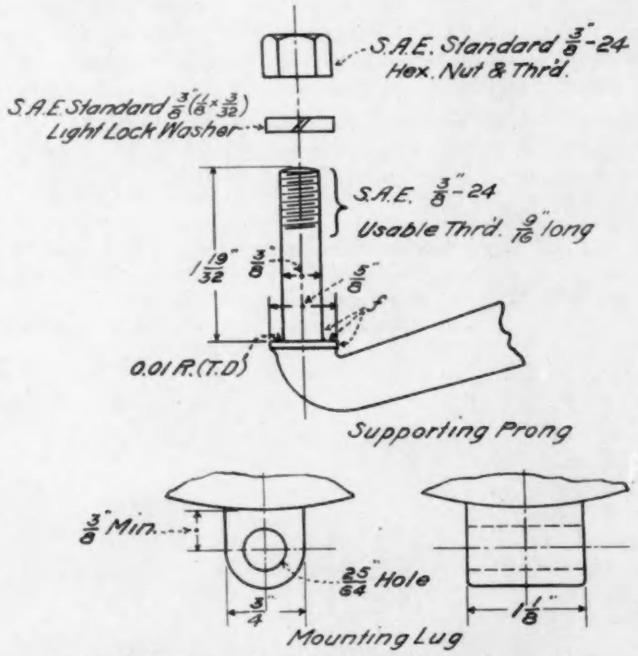
(As several methods are now in use for operating gearshifts, namely by movement of the lever up and down, or forward and backward, with high-gear position placed either front or rear, the Division considers it advisable that further standardization be held in abeyance for the time being.)

Carrying Capacity. The maximum sprung load-carrying capacity on military motorcycles and side-cars shall not exceed 500 lb., this including the operator. No load to be strapped or attached to any part of the frame of either the motorcycle or side-car, except that two rifles and boots may be attached to the front fork.

Tires on military motorcycles, rear and side-cars, shall be of the clincher type, 28 by 3 inch.

Magneto Dimensions.—In arriving at the magneto dimensions recommended below the leading makes of magnetos were studied and the space allowed on the motorcycles given careful consideration.

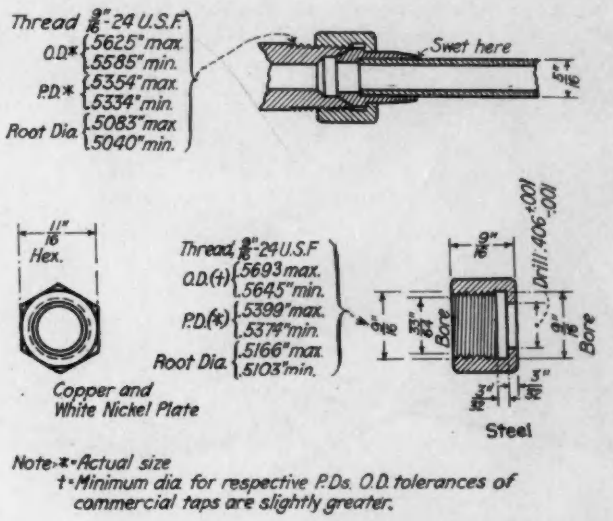
	Mm.	In.
Shaft height	45.0	1.771
Distance from center of front base-plate holes to large end of shaft taper	39.4	1.551
Distance from center of front base-plate holes to center of rear base-plate holes	50.0	1.968
Distance between centers of base-plate holes left to right	50.0	1.968
Large diameter of taper	13.0	0.5118
Small diameter of taper	11.2	0.4409
Length of taper	9.0	0.3543
Taper 1:5 (included angle) 11 deg. 30 min. approx. Woodruff key special 5/16 by 5/32 by 3/32-in. thick, set to project 1/16 in.		
Height of magneto space	152.4	6.000
Length of magneto space (from large end of shaft taper)	161.93	6.375
Width of magneto space	95.25	3.750
Width at brushes	101.6	4.000
Plain hole timing lever	5.55	0.2185
Base-plate holes 3/8-in., 16 threads per inch, U. S. Standard.		
Thread for end of magneto shaft 5/16 in. dia., 18 threads per inch U. S. form. Length of thread, 0.417 in.		
Advance lever, radius	50.0	1.968



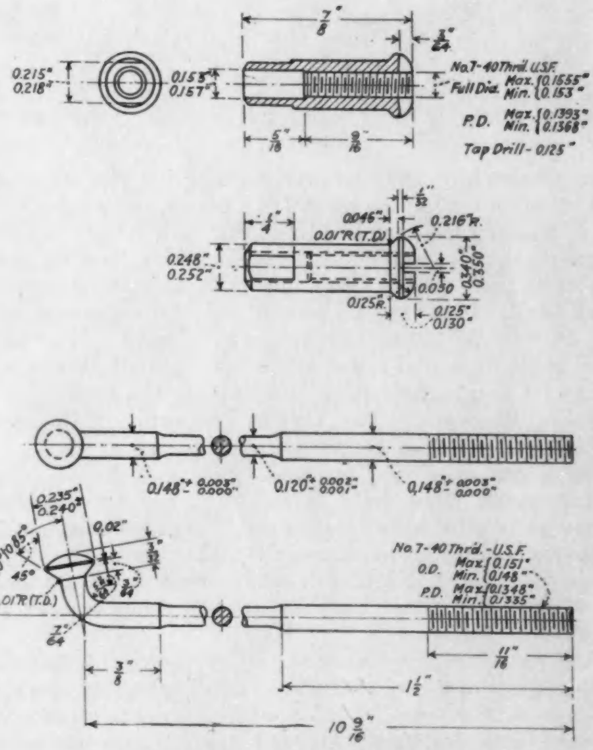
HEAD-LAMP LUGS AND SUPPORTING-PRONG DIMENSIONS

Head-Lamp Mounting Lugs and Supporting Prongs. The mounting lugs and supporting prongs shown in the accompanying sketch are recommended; these conform to existing practice.

Fuel and Lubrication Pipe Fittings. Fuel and lubrication pipes on military motorcycles shall be 9/16 in. outside diameter. The fittings shall be of the soldered type, with ½-in. nut, 24 threads to the inch, United States form.



FUEL AND LUBRICATION PIPE FITTING DIMENSIONS



SPOKE AND NIPPLE DIMENSIONS

Spoke and Nipple. The general dimensions and tolerances of the finished spokes and nipples for military motorcycle wheels shall be as shown in the accompanying drawing. The thread tolerance shown is without plating.

Threads may be either cut or rolled, but the unthreaded portion of butt must remain 0.148, + 0.003, — 0.000 inch.

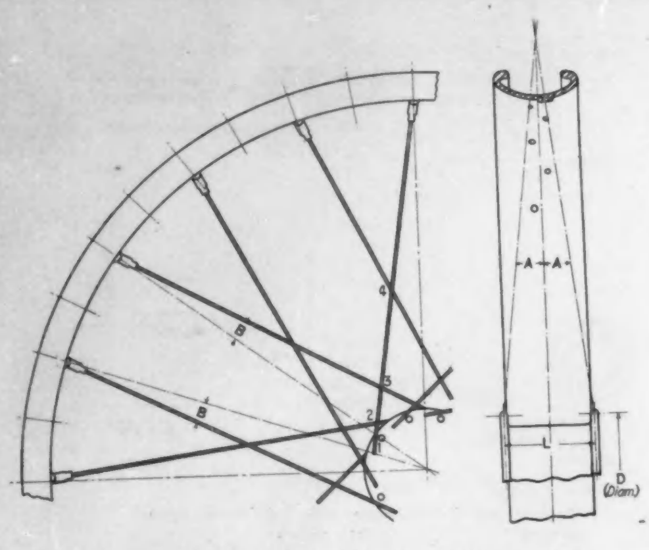
The nipple is to be made from free-cutting steel screws stock and is to be finished according to dimensions.

Spoke-Wire Specification. The spoke wire shall have the following chemical content within the limits specified:

Carbon, 0.40 to 0.55; manganese, not under, 0.50; phosphorus, not over, 0.05; sulphur, not over, 0.05.

Tolerance of Diameter. The nominal wire diameter must be 0.148, + 0.000, — 0.001 inch.

Bend Test.—The wire must be held firmly in a pair of jaws so that it may be bent over a surface having a



DIMENSIONS FOR MOTORCYCLE-WHEEL LACING AND HUBS

	A Deg. Min.	B Deg. Min.	D In.	L In.	I In.	K In.
Nominal...	6	7 30	2.86	2.93	0.165	0.255
Maximum..	7 45	9 15	3.56	3.60	0.180	0.263
Minimum..	4 15	5 45	2.20	2.25	0.150	0.247

radius of one-half the nominal diameter of the wire, and shall stand a test of at least four bends, counted as follows: Holding the free length of the wire loosely between clamps so that it cannot bend except at the holding jaws, it is to be bent 90 deg. over one jaw; this to be counted as one bend. It is then to be bent up to its original position; this to be counted as the second bend. It is then to be bent 90 deg. to the other side (third bend) and back to its original position to complete the test.

Tensile Strength. The tensile strength of the wire is to be not less than 140,000 lb. per sq. in.

Tensile Strength of Complete Spoke and Nipple. The finished spoke, when held at the bent end in the same manner as by the hub flange in a finished wheel and at the threaded end by a standard nipple with the spoke threads filling all the nipple threads, must sustain a dead load of not less than 1580 lb. No torsion test is required.

Wheel and Rim Specification. In determining the size of rim and spoke lacing there was found to be considerable variation in the number of spokes, rim punching, but the manufacturers finally agreed upon the present recommendation.

This provides for a 28 by 3-in. clincher tire with 40 spokes laced four across. The circumference of the wire-wheel rim after lacing must be 68.722, + 0.047 (3/64), — 0.172 (9/64) in.

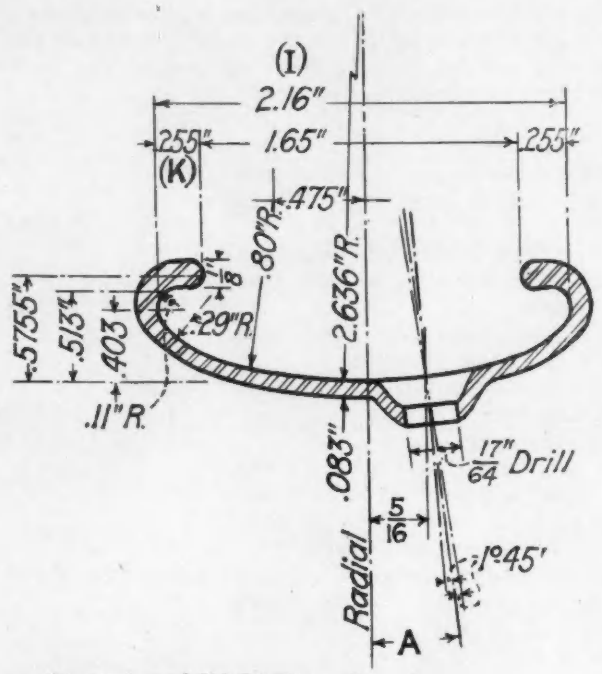
The chemical content of the steel used for the rims must be:

Carbon, 0.10 to 0.15; sulphur, not over, 0.05; phosphorus, not over, 0.05; manganese, 0.40 to 0.60.

REPORT OF ROLLER-CHAIN DIVISION

(As accepted for submission to mail vote)

The nomenclature for component chain parts, as shown in the accompanying drawing, is recommended in order to establish universal practice among both the manufacturers and the trade. The Division has worked jointly with the A. S. M. E. Chain Committee in making these recommendations, and also in preparing the dimensions included in this report.

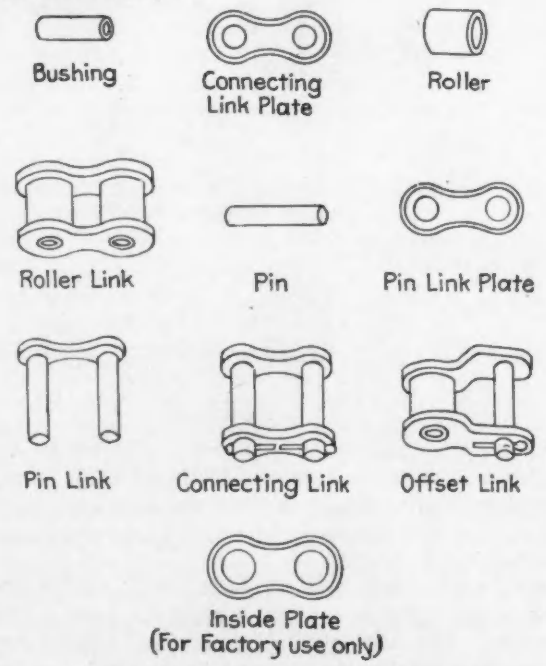


Standard "CC" Rim Section

TABLE OF ROLLER CHAIN DIMENSIONS

Trade No.	Pitch	Chain Width*	Roller Diameter
Universal 2	1/2	1/4	0.306
Universal 2 1/2	5/8	3/8	0.400
Universal 3	3/4	1/2	15/32
Universal 4	1	5/8	5/8
Universal 5	1 1/4	3/4	3/4
Universal 6	1 1/2	1	7/8
Universal 7	1 3/4	1	1
Universal 8	2	1 1/4	1 1/8
Universal 10	2 1/2	1 1/2	1 9/16

*Distance between the inside plates. All dimensions are in inches.



NOMENCLATURE FOR ROLLER CHAIN PARTS

Roller Chain Dimensions. The sizes recommended are selected from those most generally in use, with the addition of a $2\frac{1}{2}$-in. pitch for heavier duty. Other sizes will be worked out for light duty at high speeds, and heavy duty at slow speeds, and will be influenced more or less by the future introduction of alloy steels in chain manufacture. The chain-size numbers indicate the number of quarter inches in the pitch, and the word "Universal" indicates recommended standard series.

REPORT OF TIRE AND RIM DIVISION

(As accepted for submission to mail vote)

As there was no quorum present at the last meeting of the Tire and Rim Division, which was held Dec. 10 in Detroit, the minutes were sent to the members of the Division for approval. The replies received indicated that the following subjects were approved for standardization:

Solid-Tire Demountable-Rim Equipment. It is recommended that the demountable solid-tire equipment shown on War Department drawing T-101 be offered for standard service and for use only when demountable equipment is desired.

Types and Dimensions of Pneumatic-Tire Rims. It is recommended for standard practice straight-side type of rims be used for all sizes, except for 3-in. and 30 by $3\frac{1}{2}$-in., when clincher type only should be used. (This notation is to be added to S. A. E. Data Sheet 8g.)

Profile, Sizes and Types of Rims. It was recommended that S. A. E. Data Sheets 8f and 8g be combined, so as to make a more comprehensive sheet, with the subjects listed as follows:

(a) Drawings of rim contours.
(b) Table of sizes (same as shown on Data Sheet 8g).
(c) Routine tests (same as shown on Data Sheet 8f).
(d) For standard practice use straight-side type of rim for all sizes except 3-in. and 30 by $3\frac{1}{2}$-in., when clincher type only should be used.

Pneumatic Tires for Motor Trucks. It is recommended that the straight-side section be standardized with rim profiles according to the recommendations of the Tire and Rim Association for 6, 7, 8, 10 and 12-in. rims, and that the rim base-diameter be 24 in., as shown in the following table:

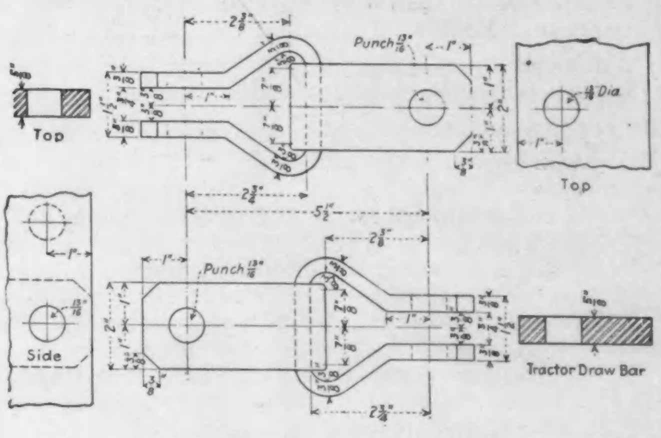
Nominal rim size, in.	Rim widths (width tire seat)	Tire sizes for 24 in. rim dia.
6	4.33	36 x 6
7	5.00	38 x 7
8	6.00	40 x 8
8	6.00	42 x 9
10	7.33	44 x 10
12	9.00	48 x 12

Motorcycle Rims. In view of the fact that the lighter types of motorcycles make use of the BB section rim, and the heavier type of the CC section, it is recommended that these two types be standardized and that the S. A. E. Handbook contain a drawing showing these sections.

REPORT OF TRACTOR DIVISION

(As accepted for submission to mail vote)

Tractor and Implement Drawbar Connectors. It is recommended that for tractors with 20 drawbar hp. or less the tractor drawbar be horizontal and $\frac{5}{8}$ in. thick, with 13/16-in. holes located with centers 1 in. from the



TRACTOR AND IMPLEMENT DRAWBAR CONNECTOR DIMENSIONS

edge of the bar; that implements be made with drawbars vertical, $\frac{5}{8}$ in. thick and with 13/16-in. holes located with centers 1 in. from the edge of the bar; and that a number of additional holes be provided in both tractor and implement drawbars to take care of any adjustment found necessary.

Magneto Mounting. It is recommended that the National Gas Engine Association standard distance of 2.375 in. from the large end of the magneto shaft taper to a point $\frac{3}{4}$ in. back from the end of the $\frac{3}{4}$-in. engine shaft be standardized. When magneto is to be mounted on an iron or steel bracket a shim at least $\frac{1}{2}$ in. thick, made from brass, aluminum, or other non-magnetic material, should be used and be furnished by the engine builder, so the standard distance from top of shim to center of magneto shaft will be 1.771 in. (the height previously standardized by the Society), and also that brass bolts be used to hold down the magneto.

S. A. E. Standards for Tractor Service. The Division recommends the following list of existing S. A. E. standards (Vol. I, S. A. E. Handbook) as suitable for tractor work:

Name	Data Sheet No.
Spark-plug shells	3
Screws and bolts $\frac{1}{4}$ to $1\frac{1}{2}$ in.	4
Sizes of taps and drills	4a
Large diameter thread ($1\frac{5}{8}$ to 6 in.)	4c
Lock washers	5
Square broached fittings	7
Taper fittings	7a
Taper fittings with castle nuts	7e
S. A. E. Steels and heat treatments	9 to 9q
Babbitt metal	11
Brass casting metals	12
Cast manganese bronze	12a
Manganese bronze sheets and rods	12b, c
Hard cast and gear bronze	12d
Aluminum alloys	13
Non-ferrous metal tubing	13c
Round tension test specimen	15
Flat tension test specimen	15xa
Flat tension test specimen	15a
Shock test specimen	15xb
Gray-iron test specimen	15b
Gray-iron test specimen	15c
Brinell hardness test	15xd, d

Cold-drawn seamless steel tubes..............16
S. A. E. bands and strips....................17
Ball and roller bearings.....................29 to 29e
Clamps and fittings for rubber hose............37
Oversize cylinders...........................47

Tractor Specification. The following condensed specification is recommended for standardization:

1. Firm name.....................................
   Address ....
2. Tractor trade name.............model............
3. Drawbar horsepower S. A. E. tractor rating........
   Old trade rating.................................
4. Belt horsepower S. A. E. tractor rating............
   Old trade rating.................................
5. Engine: Make......in. bore.....stroke........in.
   No. cylinders........cycle.......normal r.p.m.....
   Lubricating system.....................type.....
   Ignition ....Carbureter..............
   Fuel system......................................
   Cooling system...................................
   Belt pulley, dia......in......face......in......rpm.
6. Transmission type or make........................
   No speeds forward................................
   Speed in m.p.h. at normal engine speed—
   1st ....2d.............3d.............
   Indicate by check (x) speed normally used for plowing
7. Wheels: No.............arrangement............
   Driving No........dia.........in...face........in.
   Non-driving No......dia......in.....face......in.
   If of track-laying type, No. of trucks..............
   Length......................in. Face.........in.
8. Frame construction..............................
9. Wheelbase ....in....gage.............in.
10. Width over all.......in. Length over all.......in.
11. Turning radius (½ dia. largest track circle).....ft.
12. Weight of tractor, less fuel, oil, water and lugs....lb.
13. Shipping weight, including standard equipment and stays ....lb.

Banking of Automobile Speedways

By S. E. SLOCUM* (*Member of the Society*) ILLUSTRATED WITH CHARTS

IT would seem as if no definite rules were followed in laying out automobile speedways in this country, from the instances which have come under the author's observation, and that very little is known about such fundamental questions as to what makes a track "fast" or "slow," or why, on some tracks, a car shows a dangerous tendency to skid when entering or leaving the straightaway. Since the construction of a speedway involves a large investment with considerable uncertainty as to the financial returns, it is good insurance to employ correct principles of construction. As a faulty layout endangers the lives of the drivers no precaution should be neglected that will tend to make the track safe as well as speedy. This article explains the method of laying out the plan or alignment of the tracks, and it is believed that the equation of the banking curve is derived for the first time.

In laying out the plan of the track it is, first of all, necessary to make provision for passing from the circular arc at the turn into and out of the straightaway. The author happens to know of one case in which this was accomplished by using two circular arcs between each end circle and the straightaway, making the end of the track what is known as a five-centered ellipse. The defect of this construction is not apparent to the eye, yet it was found to be impossible for a car to enter or leave the straightaway without slowing down. The trouble with this layout is that the radius of the curve changed abruptly in passing from one circular arc to the next. The radius of the curve must change gradually in order to make the transition properly. The best curve for this purpose is a cubic parabola, having as its equation

$$x = \frac{y^3}{6rL}, \tag{1}$$

where r denotes the radius of the circular curve, and L the total length of the transition curve. The radius of curvature R at any point (x, y) of this curve is given by the expression

$$R = \frac{(4r^2L^2 + y^4)^{3/2}}{8r^2L^2y}. \tag{2}$$

This cubic parabola is especially convenient when laying off the transition curve by ordinates, x, measured from the tangent, or Y axis, that is, from the axis or center line of the straightaway prolonged.

Usually it is more convenient to lay off the transition curve by chords and deflection angles, measured from the point of contact of the transition curve and the straightaway. For this purpose a more suitable equation for the transition curve is

$$x = \frac{l^3}{6rL}, \tag{3}$$

where l denotes the distance measured along the transition curve from its point of contact with the tangent, instead of along the tangent. This curve is often used in railroad work, and will be called the transition spiral in what follows.

The most important advantage gained by using this transition spiral is that at any point of the curve the elevation required for banking is proportional to the distance of this point from the entrance to the transition spiral, measured along this curve. For example, suppose the proper cross-section, or bank, for the circular curve has been determined as explained below, and that the elevation of a certain point of the track has been found to be 12 ft. Then at the middle of the transition curve, measured along a parallel curve through the given point, the required elevation will be 6 ft.; at the quarter point it will be 3 ft. The use of this curve not only saves a vast amount of calculation in the office and measurement in the field, but also makes the angle of tip for a machine on any part of the track change gradually, as well as making the radius of curvature vary uniformly.

To lay out the alignment or plan of the track, the following relations are necessary.†

*Professor of Machine Design, University of Cincinnati.

†See Allen; Railroad Curves and Earthworks.

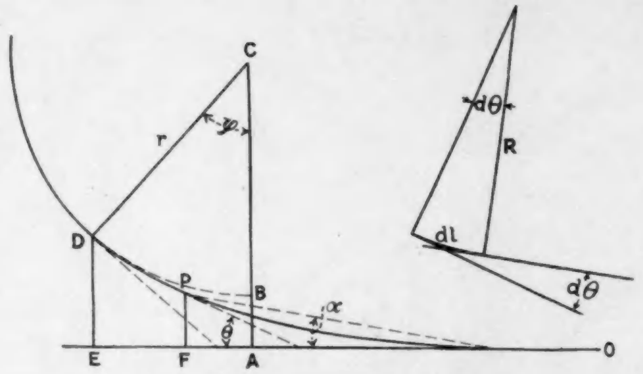


FIG. 1—LAYOUT OF TRANSITION SPIRAL

The length and curvature of the transition spiral depend on the radius, r, of the end circle and its offset, AB (Fig. 1), from the tangent. These are evidently determined by the space available for the location and are not part of the problem under discussion.

Let R denote the radius of curvature of the spiral at any point and r of the circle. Also let l denote the distance of any point on the spiral from O measured along the curve, and L the total length, OD, of the spiral. Then from the properties of the curve we have $Rl =$ a constant, and therefore $Rl = rL$. Also, since arc $=$ radius $\times$ central angle, we have

$$Rd\theta = dl \quad \theta = \frac{l^2}{2rL} \cdot \varphi = \frac{L}{2r} \tag{4}$$

Since arc $BD = \varphi r$ we have $L = 2$ arc BD. (5)

Point O is determined by making use of the relation that if a and b are the sides of a right angled triangle and c is the hypotenuse.

$$c^2 - b^2 = a^2, \text{ whence, } c - b = \frac{a^2}{c+b} \tag{6}$$

If a is small as compared with b or c, then $c - b$ equals approximately $\frac{a^2}{2c}$. In the present case any element of the spiral forms with its vertical and horizontal projections an elementary triangle of sides dx, dy and hypotenuse dl. Since dx is small in comparison with dl we have

$$dl - dy = \frac{dx^2}{2dl} = \frac{l^4 dl}{8r^2L^2} \tag{7}$$

whence by integration

$$l - y = \frac{l^5}{40r^2L^2}. \tag{8}$$

$$OA = OE - DC \sin \varphi \qquad \text{Fig. 1} \tag{9}$$
$$= y - r \sin \varphi \tag{10}$$
$$= l - \frac{l^5}{40r^2L^2} - r \sin \varphi \tag{11}$$

To determine the deflection angle α to any point P on the spiral we have $\sin \alpha = \frac{x}{l}$ approximately, or, since α is always small it is permissible to assume that

$$\alpha = \frac{x}{l} = \frac{l^2}{6rL} = \frac{\theta}{3} \text{ (from 3 and 4)} \tag{12}$$

Similarly for the point D we have $\alpha_d = \frac{\varphi}{3}$, and therefore by proportion $\alpha : \alpha_d = l^2 : L^2$, whence

$$\alpha = \alpha_d \left(\frac{l}{L}\right)^2 = \frac{\varphi}{3}\left(\frac{l}{L}\right)^2 \tag{13}$$

which determines the deflection angle to any point P in terms of its distance l from the point O, measured along the curve.

The use of the transition spiral is familiar to all railroad engineers, although it seems to have never been applied to speedway design. In practice the length of the spiral L is divided into a certain number of equal parts, usually 10, and points on the spiral located from O by successive chords of this length and their corresponding deflection angles α.

The problem which seems to have never been solved is the determination of the proper cross-section, or curve of banking, for the speedway. This may be obtained as follows:

Let AB (Fig. 2) denote the width of the track, c the radius of curvature at the inner edge A, and x, y the coordinates of any point P on the surface of the track. Let W denote the weight of the car and F the centrifugal force acting on it. Then $F = \frac{Wv^2}{gR}$ where v denotes the speed, and g is the acceleration due to gravity. In order that there may be no tendency for the car to skid, the resultant, K, of these two forces F and W must be perpendicular to the track. In order for this to be the case, the slope β of the track at any point P must be such that

$$\tan \beta = \frac{F}{W} = \frac{v^2}{gR}. \tag{14}$$

Moreover, provision must be made for cars of different speed, the faster cars traveling nearer the outside of the track, and the slower cars nearer the inside. Assume therefore that $v = a + bx$, where a and b are constants. Also the radius of curvature at P is $c + x$, and consequently

$$\tan \beta = \frac{(a + bx)^2}{g(c + x)} \tag{15}$$

Since the slope of any curve is denoted by $\frac{dy}{dx}$, we have $\frac{dy}{dx} = \tan \beta$, or

$$\frac{dy}{dx} = \frac{(a + bx)^2}{g(c + x)} \tag{16}$$

which is the differential equation of the required curve. Expanding this expression and integrating we have

$$y = \frac{1}{g}\left[\frac{b^2x^2}{2} + (2ab - b^2c)x + [a^2 - c(2ab - b^2c)] \log (x + c)\right] + K \tag{17}$$

where K denotes the constant of integration. To determine K we use the condition that $x = o$ when $y = o$, from which we find

$$K = -\frac{1}{g}[a^2 - c(2ab - b^2c)] \log c. \tag{18}$$

The equation of the curve then becomes

$$y = \frac{1}{g}\left[\frac{b^2x^2}{2} + (2ab - b^2c)x + (a - bc)^2 \log_e \frac{x + c}{c}\right] \tag{19}$$

This will be called the non-skid curve.

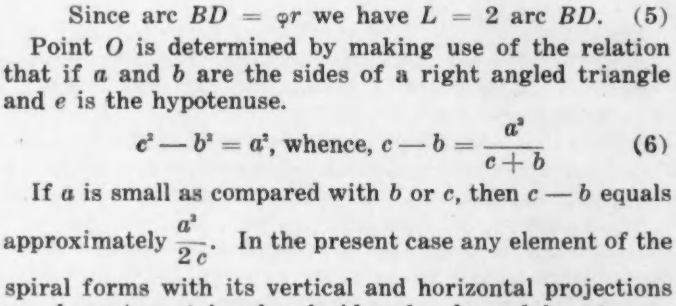


FIG. 2—DIAGRAM TO DETERMINE PROPER BANKING CURVE

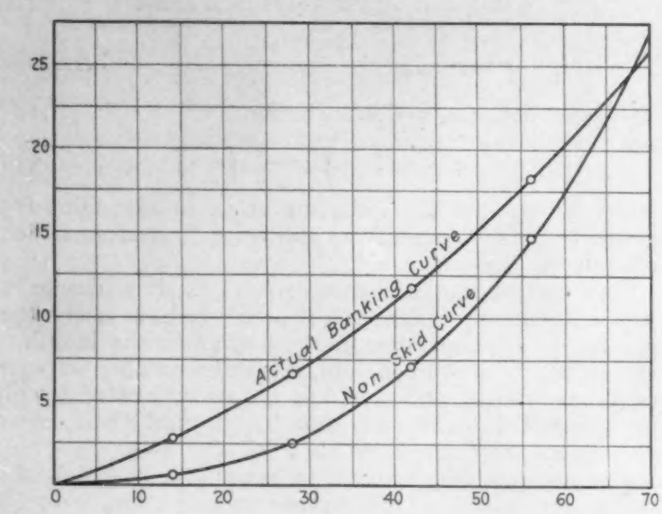


FIG. 3—DIAGRAM TO SHOW DIFFERENCE BETWEEN BANKING CURVES

To exhibit the form of this curve and compare it with the cross-section recently built which proved to be poorly designed, the following data taken from this speedway will be used.

Width of track, 70 ft. Speed at inner edge, 10 m.p.h. = 14⅔ f.p.s. Let $a = 15$; speed at outer edge, 120 m.p.h. = 176 f.p.s., giving $176 = 70b + 15$, whence $b = 2.3$; radius of inner circumference, $c = 850$ ft.

Dividing the width into five equal parts, each of 14 ft., we have the following results:

Distance from inner edge, x; 0, 14.0, 28.0, 42.0, 56.0, 70.0
Elevation above inner edge, y; 0, 0.6, 2.5, 7.1, 14.7, 27.2

The comparison (Fig. 3) has been made clearer by using a vertical scale of twice the horizontal scale.

From an inspection of these curves it is apparent why the track is slow, as the banking slope at the outside is much less than required for a speed of 120 m.p.h. By comparing the slope of the tangent at the extreme edge with a parallel tangent to the non-skid curve, it is evident that the bank is only what it should be for a speed of about 60 m.p.h.

Developments In Aluminum Castings

By H. T. KRAMM* (*Member of the Society*) INDIANA SECTION PAPER

ABOUT four years ago I installed a small melting furnace in my cellar at home and spent my evenings there for six months. At first my combination of metals and chemicals gave surprising results; some were hard and brittle, some as soft as lead. Other results were honeycombed and as rotten as a sponge. One turned out apparently fine, and on the next day oxidized and crumbled to a fine powder. Some of these results were expected, others were surprises, as the turning point of a mixture of two metals is very decided.

After three months' work I found that I could get a hard but brittle casting or a soft casting without tensile strength. I then turned my attention to finding a means of combining strength and malleability. After three months more I found the desired chemicals to combine the two qualities and called the product "maluminum," which was a shortening of the two words "malleable aluminum." It has a silver white color, a specific gravity of 2.82, a coefficient of linear expansion of 0.000019. Chilled castings show a scleroscope hardness of 24; the tensile strength of sand castings is 18,000 to 22,000, and of chilled castings 20,000 to 32,000 lb. per sq. in. The chemical composition is about 90 per cent aluminum, 6 per cent copper, and 4 per cent zinc.

After perfecting "maluminum," I experimented with it as a bearing metal. Bushings of phosphor bronze, white brass and "maluminum" chilled were turned and given the same test. I first placed the white brass under a load at a certain speed, ran the engine for two hours, and obtained a temperature of 300 deg. on the spindle. I then turned off the oil supply and melted the bushing in three minutes.

I next used the phosphor bronze bushing and obtained 300 deg. on the spindle in one hour; in three minutes after turning off the oil the bearing began to bind, and I shut down.

Next I inserted the "maluminum" bearing, and after a run of two hours and thirty minutes obtained a temperature of only 176 deg. I then turned off the oil, as I had on the two previous tests, and the engine ran one hour and fifty-five minutes more before the temperature of the spindle rose to 300 deg.

Examination of the oil from these tests under a microscope showed particles in the maluminum-test oil just perceptible at 80 diameters. The other oils showed particles apparently ½ in. diameter.

The first user of the new metal was a manufacturer in the office appliance field, who found that on intricate parts the former breakage of 25 per cent was reduced to 2 per cent and that the machining time was cut in less than half.

Piston Construction

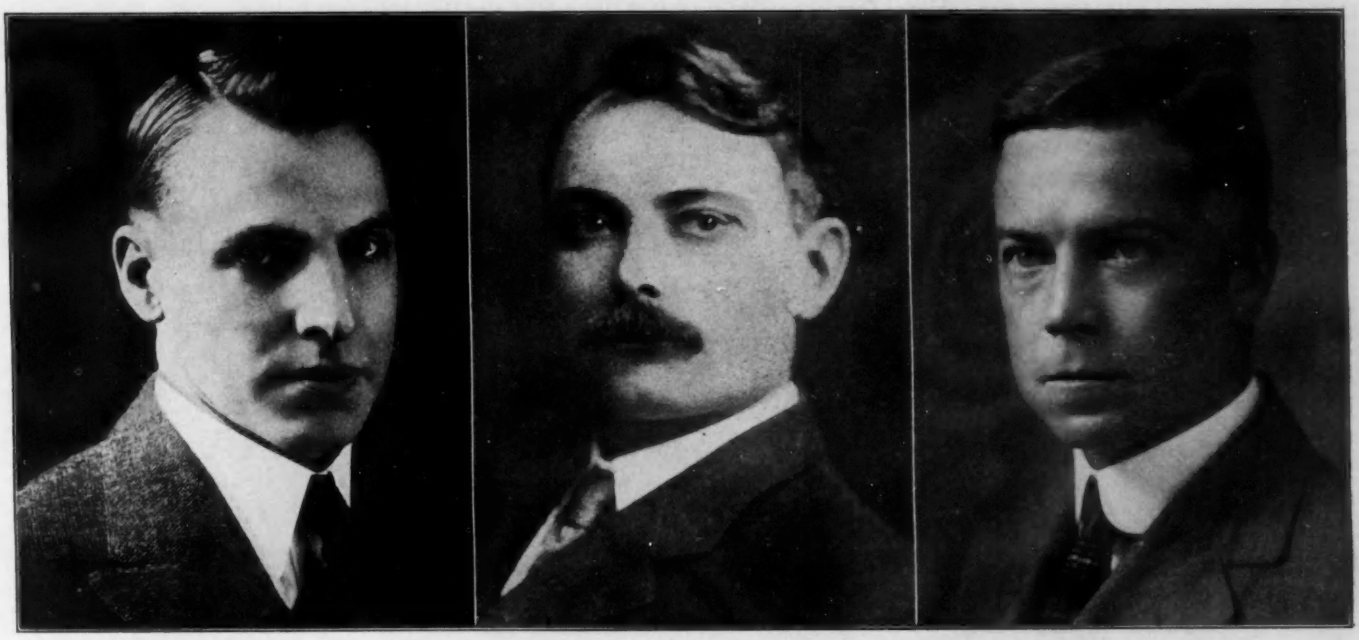
I made my first set of pistons in 1915 for Bob Burman for the Indianapolis 500-mile race. These were 3⅝-in. diameter and weighed 24 oz. I made another set for the 1916 race that measured 3 11/16 in. diameter and weighed 11 oz., the head being ⅛ in. and side walls 0.040 in. thick. These pistons drove the car at 96 m.p.h. Aluminum pistons are now usually made with heavy heads and heavy tapered side walls.

Our pistons are made in a special machine having an outside cast-iron die for chilling and a dry sand core inside. Any casting poured between two chills must necessarily be porous, because the two sides chill first, forcing the heat to the center and causing oxides to form.

This casting swells when heated and when cooled does not return to the original size; each heating and cooling enlarges the casting; thus driving the heat through the casting to the core and leaving no porosity in the metal.

Our piston machine is so made that we can obtain castings to any degree of hardness from 11 to 24 on the scleroscope, and with a variation of not more than two degrees of hardness. This uniformity of hardness means that our castings all wear alike. They do not show different degrees of wear in every cylinder.

*General manager, Kramm Foundry Company.



Minneapolis Section Officers: H. C. Buffington, Secretary; W. J. McVicker, Vice-Chairman, and E. R. Greer, Chairman

Activities of S. A. E. Sections

THE Detroit, Indiana and Metropolitan Sections held no meetings during January on account of the Annual Meeting of the Society and because of the show activities during the month. Practically all the other Sections met in January and all of them are planning to hold a February meeting. The most important section event was undoubtedly the conference held on Jan. 9 in New York in connection with the Annual Meeting. This was attended by representatives of all but two of the sections and the discussion that took place was of great interest. A brief account of the meeting is given on page 104.

The Buffalo Section of the Society is to present a paper at the Feb. 6th meeting of the Buffalo Engineering Society. Arrangements have been made to have C. C. Carpenter, chief chemist of the U. S. Light & Heat Corporation, discuss the subject of storage batteries.

The January meeting of the Cleveland Section was held on the 18th, when H. B. Baker, Holt Tractor Co., gave a paper on the advancement made in caterpillar-type tractors. At the meeting to be held Feb. 15 O. W. A. Oetting, of the Willard Storage Battery Co., will speak on the cold weather effects on automobile starting.

The Detroit Section did not hold a meeting during January in order to allow the members to devote all of their time to the various automobile shows. In February J. Edward Schipper of the Class Journal Company will present a summary of the engineering features of the exhibits at the automobile shows.

The Indiana Section meeting in February will take place on the 8th, when a paper on Flexible Universal Joints will be presented by C. A. Schell, chief engineer of the Thermoid Rubber Company.

The Metropolitan Section is cooperating with the Meetings Committee of the Society in arranging the Motorboat Meeting that will be held on the 25th at New York. This will consist of a dinner in the evening at the Automobile Club of America, followed by the presentation of technical papers.

At the January meeting of the Mid-West Section, which was held on the 18th at the Chicago Automobile Club, Francis A. Carlisle, general manager of the Friedlander Brady Knitting Mills, read a paper on Efficiency in Factory Production. In addition H. B. Baker of the Holt Mfg. Co. showed some motion pictures featuring the tractors in use in the United States Army.

The subject of tractor radiation was discussed by Arthur S. Modine, president of the Modine Mfg. Co., at the Jan. 2d meeting of the Minneapolis Section. The paper developed a number of formulas for use in designing radiators, and contained recommendations relating to water circulation, air velocity and fan details.

At the February meeting to be held on the 6th a paper on Tractor Fuel will be given by Prof. J. L. Mowry of the Engineering Department of the Minnesota Farm School.

The January meeting of the Pennsylvania Section will be held on the 24th at the Engineers' Club of Philadelphia. It is expected that a paper will be presented on Upholstery as an Element in the Easy-Riding of Motor Cars.

Conference of Section Officers

The meeting to discuss Section affairs held on the 9th in New York was attended by representatives of the Cleveland, Detroit, Metropolitan, Mid-West, Buffalo and of the proposed Boston and San Francisco Sections, as well as by members of the Sections Committee.

Chairman Hinkley of the Detroit Section told of the effect he had experienced as a result of the recent increase in dues for section associates. He stated that many section associates had been interested even at the increased dues.

The proposal to amend the Constitution of the Society

MINNEAPOLIS SECTION OFFICERS: C. T. STEVENS, CHAIRMAN, MEETINGS AND PAPERS COMMITTEE; O. W. YOUNG, CHAIRMAN, MEMBERSHIP COMMITTEE, AND J. L. MOWRY, CHAIRMAN, RESEARCH AND DATA COMMITTEE

so as to make the Sections Committee one of the regular administrative committees was discussed. It was emphasized that this committee need not necessarily be composed of section chairmen, as is the present Sections Committee, but that it was considered desirable to have men experienced in section work but who were not actively engaged in it. The duties of this new committee would be mainly to promote the work of the present sections and help to found new sections wherever possible.

Conferences Valuable

The conferences of section officers, which are now being held twice each year, will still be continued, inasmuch as they have been found of value to those who are carrying on the local activities. It was voted after considerable discussion to be the sense of the meeting that an amendment should be made providing for a Sections Committee as one of the standing administrative committees.

Most of the sections at present are using different stationery, so that there are as many types as there are sections. This matter was discussed at the meeting and the suggestion was made that the Society could handle it through its better purchasing facilities and arrange to have the letterheads for the different sections dealt out as required. It was finally decided to be the sense of the meeting that the section stationery should be uniform and follow the style of the letterhead used by the Society, each section to have the names of its officers printed thereon.

Proposed Sections

H. W. White, Jr., of San Francisco and Messrs. Hopewell and Northway of Boston were called upon and discussed the possibilities of sections in their localities. The automotive manufacturing industry is growing rapidly on the Pacific Coast and it is believed that a strong section could be organized there. There are a large number of members of the Society in Boston and steps will be taken to get them together for their mutual benefit and for the good of the Society.

General Problems

The final event of the conference was the discussion of general section problems. Chairman Hinkley of Detroit told how he had arranged for a season of successful section meetings by taking the subject nearest at hand (the production work being actually done in the city of Detroit) and weaving a romance around it, the result being that everyone is interested and a large attendance is being secured.

Chairman Whitney of the Mid-West Section emphasized the importance of securing the right men for places on the different committees. He told how the Mid-West Section had formed an organization to make arrangements for the War Dinner that will be held Feb. 1 at Chicago and how they were working together, holding weekly and sometimes daily meetings to make this dinner a big success.

Membership Increase

Vice-Chairman Kebler of the Metropolitan Section spoke on membership methods, suggesting that a number of prominent members of each section be asked to write special letters regarding the advantage of section membership. It was then proposed by Reuben Allerton, chairman of the Membership Committee of the Metropolitan Section, and approved by the meeting, that the chairman of the section membership committees ought to be affiliated with the Membership Committee of the Society. It was also suggested that when members of the Society moved from one section territory to another information regarding their change of address should be given to the new section so that they could be invited to take active part in the work.

REPORT OF JANUARY COUNCIL MEETING

THE final meeting of the 1917 Council was held Jan. 9 at the office of the Society at New York, those present being Vice-President Charles M. Manly, Councilors B. B. Bachman, David Beecroft, H. L. Horning, F. E. Moskovics, John G. Utz, Treasurer Herbert Chase, and Secretary Coker F. Clarkson.

Chairman Beecroft of the Meetings Committee reported that the program for the Annual Meeting was completed and that all the tickets for the dinner had been sold; also that over 900 tickets for the Chicago War Dinner had been sold. Arrangements have been made for holding a Motorboat Meeting on Jan. 25, together with a dinner. The details of these are to be carried out by the Metropolitan Section of the Society.

A report was submitted for Chairman C. W. McKinley of the Membership Committee showing that steps had been taken to build up a strong organization.

A report was received from Councilor Bachman as chairman of the Constitutional Committee making suggestions as to revisions that should be made in the Constitution. This report is given elsewhere in this issue.

A resolution was adopted waiving the dues of members engaged in active foreign service in the military departments of the Government.

A report was received from Chairman Daniel Roesch of the Publication Committee suggesting changes in the organization of the committee so that engineers familiar with carbureter and ignition problems should be included.

E. H. Ehrman was appointed a member of the Aeronautic Division of the Standards Committee.

Reports of the Divisions submitted at the Standards Committee Meeting on the 9th were approved by the Council for presentation at the Annual Meeting.

It was announced that Charles M. Manly and E. H. Ehrman, appointed representatives of the Society at the International Conference on Screw-Thread and Aircraft Standards to be held in London, had agreed to serve in this capacity.

A report was submitted by Chairman Bachman of the Sections Committee. This stated that a conference on section affairs was to be held on the 9th and also suggested that the Sections Committee should be composed of five members who are not taking an active part in section work but who can cooperate closely with the general local activities of the Society.

The report of the committee appointed to consider securing additional office space for the New York office of the Society was approved and as a result the Society will take over the entire sixth floor of the Engineering Societies' Building.

It was voted to make the following transfers in membership: From Associate to Member, George H. Daubner, R. T. Evans, L. H. Keim, Edward S. Preston, Harry A. Scott, O. P. Tyler and L. R. Wotting.

Applicants to the number of 52 were elected to membership in the Society, these being assigned to grades as follows: 25 Members, 18 Associate Members, and 9 Junior Members.

The next meeting of the Council will probably be held Jan. 31 at Chicago.

Service Directory of Members

THE following list is intended to contain the names of all members connected with the Government either in the military services or in civilian capacities. The names are listed in two parts, the first showing the members who have actually entered the military services, and the second those engaged as civilians. Every effort is made to have the addresses correct, but many of the members are changing about so much that it is almost impossible to tell accurately as to just where they are located at any given time. It is therefore requested, in case of any error, that the member concerned immediately inform the New York Office of the Society, so that a proper correction can be made. Members who have actually entered the service in any capacity, and who are not listed, should also write the details to the New York Office.

MILITARY HONOR ROLL

Alden, Herbert W., major, Motor Equipment Section, Carriage Division, Ordnance O. R. C., A. E. F., France.

Ames, Butler, brigadier general, Mass. State Militia, Lowell, Mass.

Anderson, William C., lieutenant, Engineer O. R. C., Brooklyn, N. Y.

Arnold, Bion J., lieutenant colonel, Signal U. S. R., Washington.

Barker, C. Norman, pilot cadet, Royal Flying Corps, Camp Borden, Can.

Barton, W. E., first lieutenant, Quartermaster O. R. C., Washington.

Bibb, John T., Jr., private, Aviation Section, Signal Corps, A. E. F., France; (mail) 3rd Foreign Detachment, Cadet Flying Squadron, A. E. F., France.

Blank, M. H., first lieutenant, Motor Equipment Division, Ordnance O. R. C., Washington.

Blood, Howard E., lieutenant, Engine Design Section, Equipment Division, Signal Corps, U. S. A., Washington.

Bowen, C. H., captain, Military Truck Production Section, office of Quartermaster General, Washington.

Britten, Wm. B., captain, assistant to Officer in Charge of Transportation, Quartermaster O. R. C., Washington.

Brown, Harold Haskell, first lieutenant, Coast Artillery Corps, U.S.N.A., Fort Totten, N. Y.

Browne, Arthur B., captain, Sanitary Corps, U.S.N.A., (mail) General Motors Co., Detroit.

Callan, John Lansing, lieutenant, Reserve Flying Corps, U. S. N., U. S. S. Seattle, (mail) Postmaster, New York.

Campbell, Lindsey F., 4th Battery, 2d P. T. R., Fort Sheridan, Ill.

Clark, Edward L., first lieutenant, Signal O. R. C., McCook Field, Dayton, Ohio.

Clark, Virginius E., lieutenant colonel, Signal Corps, U. S. A., McCook Field, Dayton, Ohio.

Coe, Edw. M., first lieutenant, Quartermaster Corps, U. S. A., Washington.

Dayton, William E., private, 306th Regiment, Field Artillery, U. S. N. A., Washington.

Deeds, Edward A., colonel, Equipment Division, Signal Corps, U. S. A., Washington.

De Lorenzi, Ernest A., officer, Mechanical Transport, War Department, London, Eng.

De Witt, George W., lieutenant, U. S. Naval Militia, Jacksonville, Fla.

Dickey, Herbert L., captain, Motor Equipment Section, Carriage Division, Ordnance O. R. C., Washington.

Donaldson, Frank A., captain, Quartermaster U. S. R., U. S. A., Minneapolis.

Dost, Charles O., first lieutenant, Aviation Section, Signal Corps, U. S. A., Cornell University, Ithaca, N. Y.

Earle, Lawrence H., first lieutenant, Ordnance O. R. C., assigned as inspector of ordnance, Holt Mfg. Co., Peoria, Ill.

Eells, Paul W., lieutenant, 330th Field Artillery, O. R. C., Camp Custer, Battle Creek, Mich.

Farrell, Matthew, captain, Quar. U. S. R., Washington.

Finkenstaedt, Edward R., first lieutenant, Military Truck Production Section, office of Quartermaster General, Washington.

Fishleigh, W. T., major, Sanitary Corps, U. S. N. A., Washington, assigned as automobile engineer.

Flanigan, E. B., Officers' Reserve Training Camp, Plattsburg, N. Y.

Forrer, J. D., captain, Engineer O. R. C., Washington.

Foss, Clarence M., captain, Ordnance O. R. C., Rock Island Arsenal, Rock Island, Ill. Assigned to Motor Section.

Fox, Rudolph H., first lieutenant, Ordnance O. R. C., Washington.

Furlow, James W., lieutenant colonel, Quartermaster Corps, U. S. A., Washington, assigned to Office of Quartermaster General.

Gaebelein, Arno W., lieutenant, Ordnance O. R. C., Washington, assigned to Carriage Division.

Gardner, Lester D., captain, 117th Aero Squadron, Signal Corps, U. S. A., Washington.

Gforer, A. H., first lieutenant, Ordnance O. R. C., Washington.

Gillis, Harry A., major, Ordnance O. R. C., Washington.

Gorrell, Edgar S., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., Washington.

Gray, B. D., major, Equipment Division, Aviation Section, Signal O. R. C., Washington.

Green, Geo. A., captain, Tank Section, B. E. F., France.

Guthrie, James, major, Ordnance O. R. C., Washington, assigned to Field Artillery Section, Carriage Division.

Hall, Elbert J., major, Engine Design Section, Engineering Division, Signal Corps, U. S. A., Washington.

Harms, Henry W., captain, Av. Sec., Signal Corps, U. S. A., Washington.

Hartman, A. A., private, U. S. N. A., Camp Devens, Ayer, Mass.

Hegeman, Harry A., major, Quartermaster Corps, U. S. A., Washington, assigned to Office of Officer in Charge of Transportation.

Horner, Leonard S., major, Equipment Division, Signal Corps, U. S. A., Washington.

Howard, Walter S., first lieutenant, Military Truck Production Section, office of Quartermaster General, Washington.

Hubbell, Lindley D., major, Ordnance O. R. C., Springfield, Mass., assigned as Officer in Charge, Hill Shops, Springfield, Armory.

Jeffrey, Max L., first lieutenant, Military Truck Production Section, office of Quartermaster General, Washington.

Jennings, J. J., first lieutenant, Quartermaster O. R. C., A. E. F., France.

Joy, Henry B., major, Aviation Section, Signal O. R. C., Washington.

Kendrick, John F., Signal Corps, A. E. F. France, assigned to Research Inspection Division.

Kohr, Robert F., second lieutenant, Engineers O. R. C., Washington.

Lanza, Manfred, major, Quartermaster Corps, U. S. A., headquarters 78th Division, Camp Dix, N. J.

Larsen, Lester Reginald, second lieutenant, Engineer O. R. C., Washington.

Lavery, Geo. L., Jr., first lieutenant, Ordnance O. R. C., Washington.

Lay, Arthur J. captain, Aviation Section, Signal O. R. C., Washington.

LeFevre, Wm. G., lieutenant, Ordnance O. R. C., Washington.

Lewis, Charles B., captain, Ordnance O. R. C., Camp Lewis, American Lake, Wash.

Lewis, Harry R., Jr., first lieutenant, Ordnance O. R. C., Springfield Armory, Springfield, Mass.

Lipsner, B. B., captain, Air Division, Aviation Section, Signal O. R. C., Washington.

McIntyre, H. C., captain, Ordnance O. R. C., Washington.

McMurtry, Alden L., captain, office of Surgeon General, Sanitary Corps, U. S. N. A., Washington.

Mackie, Mitchell, adjutant, Quartermaster Corps, U. S. A., A. E. F., France, assigned to Motor Truck Transport Section.

Marmon, Howard, captain, Airplane Engineering Division, Signal O. R. C., McCook Field, Dayton, Ohio.

Marshal, W. C., captain, Ordnance O. R. C., Washington.

Martin, Kingsley G., captain, Quartermaster O. R. C., Camp Dodge, Iowa.

May, Henry, Jr., first lieutenant, Military Truck Production Section, office of Quartermaster General, Washington.

May, O. J., captain, Aviation Section, Signal O. R. C., Camp Custer, Battle Creek, Mich.

Middleton, Ray T., first lieutenant, air service, A. E. F., Paris, France.

Moffat, Alex. W., ensign, commanding U. S. S. "Tamarack" (S. P. 561), Naval Defense Reserve, Postmaster, Foreign Station, New York.

Morgan, M. B., captain, Ordnance O. R. C., Washington.

Myers, J. L., first lieutenant, Ordnance O. R. C., Washington.

Nahikian, S. M., 4th Battery, Second O. T. R., Ft. Sheridan, Ill.

Ommundson, H. P., Flying Corps, U. S. N., Aeronautic Station, Pensacola, Fla.

Pagé, Victor W., first lieutenant, Aviation Section, Signal O. R. C., Mineola, N. Y.

Paine, C. L., captain, Ordnance O. R. C., 318 North Illinois Avenue, Indianapolis, assigned to work on tanks.

Parker, Richard E., captain, Quartermaster O. R. C., Washington, assigned to Southern Department.

Pearmain, W. J., captain, Ordnance O. R. C., A. E. F., France.

Peifer, Carl B., lieutenant, Specification Section, Signal Corps, U. S. A., Washington.

Pfeiffer, Ben. S., first lieutenant, Ordnance O. R. C., Rock Island Arsenal, Rock Island, Ill., assigned to Motor Section.

Potter, Austin E., lieutenant, New York Naval Militia, Brooklyn, N. Y.

Powell, W. B., officer in charge of transportation, Imperial Ministry of Munitions, (mail) Box 94, Quebec, Can.

Pullen, Daniel D., captain, 7th Regiment, Engineer Corps, U. S. A., Fort Leavenworth, Kan.

Ranney, A. Elliot, major, Air Division, Signal Corps, U. S. A., Washington.

Rawley, Jos., captain, Co. A, 310th Engineers, U. S. A., Camp Custer, Battle Creek, Mich.

Rose, Charles B., captain, Equipment Division, Signal Corps, U. S. A., Washington.

Rosenthal, Wm. C., private, U. S. N. A., 507 Nineteen Hundred Euclid Bldg., Cleveland.

Schoenfuss, F. H., captain, Ordnance O. R. C., Washington.

Schoepf, T. N., captain, Engineer O. R. C., Washington.

Selfridge, S. W., first lieutenant, Ordnance O. R. C., Washington.

Slade, Arthur J., captain, Aviation Section, Signal O. R. C., Washington.

Smith, Mark A., first lieutenant, Marine Corps, U. S. N., Washington.

Sprague, G. A., Co. D., 310th Engineers, Camp Custer, Battle Creek, Mich.

Steinau, J. M., Sanitary Corps, U. S. N. A., Washington.

Strahlman, Otto E., first lieutenant, Aviation Section, Signal O. R. C., (mail) McCook Field, Dayton, Ohio.

Swinton, D. R., first lieutenant, Quartermaster Corps. U. S. A., assigned to Office of Quartermaster General.

Thompson, H. E., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance O. R. C., Washington.

Thomson, Clarke, lieutenant, Signal O. R. C., Washington.

Titsch, Walter H., captain, Quartermaster Corps, U. S. N. A., Washington.

Tolman, Edgar Bronson, Jr., first lieutenant, 311th Engineers, U. S. A., Camp Grant, Rockford, Ill.

Turner, Harry C., captain, Eng. U. S. R., A. E. F., France.

Twachtman, Quentin, first lieutenant, Engine Design Section, Signal O. R. C., Washington.

Vail, E. L., lieutenant, Signal Corps, U. S. A., Washington.

Vincent, Jesse G., major, Aviation Section, Signal Corps, U. S. A., Miami Hotel, Dayton, Ohio.

Vonachen, F. J., lieutenant, Ordnance Department, U. S. N. A., Rock Island Arsenal, Rock Island, Ill.

Waldon, Sidney D., colonel, Equipment Division, Signal Corps, U. S. A., Washington.

Wall, William Guy, major, Ordnance O. R. C., Washington, assigned to motorization work.

Walter, Maurice, first lieutenant, Ordnance O. R. C., Washington.

Walton, Frank, acting sergeant, Quartermaster Corps, U. S. A., assigned to Quartermaster Repair Unit, Camp Meigs.

Wetherill, S. P., Jr., major, Quartermaster O. R. C., Washington.

Whittenberger, Owen M., first lieutenant, Ordnance O. R. C., Washington, assigned to Office of Chief of Ordnance.

Wilson, T. S., major, First Indiana Field Artillery, Lafayette, Ind.

Wood, Harold F., lieutenant, Specification Section, Equipment Division, Signal O. R. C., Washington.

Recent Additions

Aldrin, Edwin E., lieutenant, Aviation Section, Signal Corps, U. S. A., Ft. Monroe, Va.

Amon, Carl H., Aviation Section, Signal O. R. C., Washington.

Boggs, Geo. A., lieutenant, Quartermaster Corps, U. S. A.; (mail) Farmers Loan & Trust Co., Paris, France.

Dimond, G. A., first lieutenant, Motor Section, Ordnance O. R. C., Ft. Herring, Peoria, Ill.

Du Bose, Geo. W. P., major, American Ordnance Base Depot, A. E. F., France.

Gey, William, 377th Truck Train, U. S. N. A., Camp Merritt, Tenafly, N. J.

Glover, F. S., major, Ordnance O. R. C., Washington.

Haeske, F. C., lieutenant, U. S. A., Camp Sherman, Chillicothe, Ohio.

Hall, Richard H., Jr., first lieutenant, Quartermaster Corps, U. S. N. A., Chevy Chase, Md.

Hoffman, Roscoe C., captain, Ordnance O. R. C., Washington, assigned to Carriage Division, Motor Equipment Section.

Kennedy, H. H., lieutenant, Ordnance Department, U. S. A., Washington, assigned as inspector of ordnance.

Kline, H. J., first lieutenant, Ordnance O. R. C., Washington.

Kottnauer, Edwin H., first lieutenant, Ordnance O. R. Co., assigned to The Nash Motors Co., Kenosha, Wis.

Lane, Abbott A., first lieutenant, Aviation Section, Signal O. R. C., Detroit, Mich.

Mergi, William, Co. B., First Battalion, 153d Depot Brigade, Camp Dix, Wrightstown, N. J.

Miller, B. F., major, Quartermaster Corps, U. S. A., Washington.

Miller, C. A., first lieutenant, Quartermaster Corps, U. S. N. A., Washington.

Moncrieff, V. I., captain, Aviation Section, Signal O. R. C., Washington.

Murphy, Joseph G., Sanitary Corps, U. S. N. A., Washington.

Oldfield, Lee W., captain, Signal O. R. C., Washington, assigned as aeronautical engineer.

Otto, Henry S., lieutenant, Intelligence Section, A. E. F., France.

Post, Edwin M., Jr., lieutenant, U. S. Air Service, A. E. F., France.

Robinson, H. A., ensign, U. S. N. R. F., Washington.

Sandt, A. R., sergeant, Ordnance Department, U. S. A., Rock Island Arsenal, Rock Island, Ill., assigned to Motor Section Instruction School.

Smith, Frank E., major, Signal Corps, U. S. A., Washington.

Strauss, N. Frank, lieutenant, Ord. R. C., Washington.

Teetor, D. C., captain, Ordnance O. R. C., Kenosha, Wis., assigned to Motor Section.

Underhill, C. R., captain, Radio Section, Signal O. R. C., Washington.

Wodehouse, B. A., sergeant, Co. A, 339th Infantry, Camp Custer, Battle Creek, Mich.

Woods, S. H., captain, Quartermaster Corps, N. A., Washington.

Civilian Honor Roll

Adams, Porter H., Office of the Section Commander, First Naval District, Rockford, Me.

Anderson, E. S., mechanical engineer, Aviation Section, Signal Corps, U. S. A., Rockwell Field, N. Island, San Diego, Cal.

Bare, Erwin L., automobile body designer, Office of Quartermaster General, Washington.

Barnhardt, Geo. E., instructor, Signal Corps Aviation School, San Diego, Cal.

Bourquin, J. F., supervisor of chassis assembly, Military Truck Production Section, Office of Quartermaster General, Washington.

Burton, W. Dean, aeronautical mechanical engineer, Signal Service, U. S. A., Fort Omaha, Neb.

Caldwell, Frank W., aeronautical mechanical engineer, Aviation Section, Signal Corps, Washington, (mail) 1449 Massachusetts Avenue, N. W.

Chapman, Robert H., U. S. N., Spartanburg, S. C., assigned to Aeronautical Division.

Chauveau, Roger, aeronautical mechanical engineer. Aviation Section, Signal Corps, Washington.

Clark, Elmer J., Signal Corps, U. S. A., Portland, Ore., assigned as district manager of inspection.

Coffin, Howard E., chairman, Aircraft Production Board, Washington.

Costello, John V., aeronautical engineer, airplane engineering division, Signal Corps, Dayton, Ohio.

DeKlyn, John H., technical assistant, National Advisory Committee on Aeronautics, Washington.

Diffin, F. G., chairman, International Aircraft Standards Board, Washington.

Edgerton, A. H., aeronautical mechanical engineer, Inspection Section, Signal Corps, U. S. A., assigned to Equipment Division.

Elliott, E. M., U. S. Public Service Reserve, Department of Labor, 1712 I Street, Washington.

Ericson, Friehof G., representative of Canada, International Aircraft Standards Board, Washington.

Fowler, Harlan D., aeronautical engineer, Aviation Section, Signal Corps, Mineola, N. Y.

Froesch, Charles, aeronautical mechanical engineer, Aviation Section, Signal Corps, Washington.

Gill, R. O., inspector of airplanes, Equipment Division, Signal Corps, (mail), Dayton-Wright Airplane Co., Dayton, Ohio.

Girl, Christian, director, Military Truck Production Section, Office of Quartermaster General, Washington.

Gorman, E. J. B., U. S. Naval Reserve Flying Corps, Dayton, Ohio, assigned to inspection of airplane engines, Dayton-Wright Aeroplane Co.

Gunn, E. G., production engineer, Quartermaster Corps, U. S. A., Washington, assigned to Motor Transportation Division.

Hale, W. A., aeronautical mechanical engineer, Signal Corps, U. S. A., Dayton, Ohio.

Hallett, Geo. E. A., aeronautical mechanical engineer, Signal Corps, Aviation School, San Diego, Cal.

Heckel, C. E., truck designer, Transport Division, Quartermaster Corps, U. S. A., Washington.

Hicks, Harlie H., airplane engineering division, Signal Corps, U. S. A., Dayton, Ohio.

Hobbs, J. W., automobile expert, Ordnance Department, Rock Island Arsenal, Rock Island, Ill.

Holden, F. M., airplane engineering division, Signal Corps, U. S. A., Washington.

Honigman, Jos. K., instructor, U. S. School of Military Aeronautics, Princeton University, Princeton, N. J.

Horine, M. C., inspector, airplane engineering division, Signal Corps, Washington.

Hoyt, F. R., Aviation Section, Signal Corps, Washington.

Kalb, Lewis P., assistant supervisor of inspection, Military Truck Production Section, office of Quartermaster General, Washington.

King, Charles B., aeronautical mechanical engineer, Aviation Section, Signal Corps, Washington.

Kishline, Floyd F., laboratory assistant, Quartermaster Corps, Washington.

Laddon, I. M., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, Dayton, Ohio.

Lane, Abbott A., inspector, Aviation Section, Signal Corps (mail), Room 52, 870 Woodward Avenue, Detroit.

McCain, Geo. L., Signal Corps, U. S. A., Dayton, Ohio, assigned to airplane engineering department, Engine Design Section.

McMaster, Marcenus D., aeronautical engineer, Equipment Division, Signal Corps, Washington.

Mennen, F. E., Quartermaster Corps, U. S. A., Washington, assigned to Transportation Division.

Morgan, G. W., supervisor of plant survey, Military Truck Production Section, Office of Quartermaster General, Washington.

Nelson, A. L., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, Dayton, Ohio.

Neumann, John W., Planning Section, Machine Division, U. S. Navy Yard, Philadelphia.

Norris, G. L., Inspection Section, Equipment Division, Signal Corps, Washington.

O'Malley, John M., instructor in motor engineering, Aviation School, Signal Corps, Washington.

Otis, J. Hawley, Ordnance Department, U. S. A., Camp Dodge, Des Moines, Iowa.

Parish, W. F., Signal Corps, U. S. A., Washington, assigned to Specification Section, Equipment Division.

Parker, Victor C., Signal Corps, U. S. A., Washington, assigned to Equipment Division.

Parris, Jr., Edward L., senior inspector, Aviation Section, Signal Corps, (mail) Ericsson Mfg. Co., Buffalo.

Perrin, J. G., assistant, Signal Corps, U. S. A., 401 Lindsey Bldg., Dayton, Ohio, assigned to airplane engineering division.

Proctor, C. D., Ordnance Department, U. S. A., Rock Island Arsenal, Rock Island, Ill. Assigned to Motor Section, Carriage Division.

Rice, Harvey M., inspector, Aviation Section, Signal Corps, (mail) Curtiss Aeroplane Co., Buffalo.

Rippingille, E. V., Aviation Section, Signal Corps, Washington.

Rogers, John M., aeronautical engineer, Bureau of Construction & Repair, Navy Department, Washington.

Salisbury, Edward V., chief of motor transportation, American International Corp., Government Shipbuilding Yard, Hog Island, Philadelphia.

Schell, John A., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, Dayton, Ohio.

Schupp, Arthur A., aeronautical mechanical engineer, Aviation Section, Signal Corps, Washington.

Serrell, Ernest, aeronautical mechanical engineer, Aviation Section, Signal Corps, Washington.

Sloane, Jno. E., Signal Corps, U. S. A., Washington, assigned to Equipment Division.

Smith, G. W., Jr., aeronautical mechanical engineer in charge of experimental division, Engineering Department, Naval Aircraft Factory, U. S. Navy Yard, Philadelphia.

Stalb, Arthur R., Jr., U. S. Navy Aeronautic Station, Pensacola, Fla., assigned as aeronautic draftsman, Hull Division.

Stanton, D. T., military instructor, U. S. Army School of Military Aeronautics, Cornell University, Ithaca, N. Y.

Stout, William B., technical advisor, International Aircraft Standards Board, Washington.

Thibault, F. J., aeronautical mechanical engineer, Signal Corps, U. S. A., Washington.

Tone, Fred I., inspector, Aviation Section, Signal Corps, Washington.

Tracy, Percy Wheeler, supervisor of parts plants, Military Truck Production Section, Office of Quartermaster General, Washington.

Utz, John G., supervisor of inspection, Office of Military Truck Production Section, Office of Quartermaster General, Washington.

Van Loon, Henry M., 310th Engineers, Camp Custer, Battle Creek, Mich.

Wade, Gustav, inspector, Aviation Section, Signal Corps, Washington.

Waldron, Russell E., Signal Corps, U. S. A., Detroit, assigned to Equipment Division.

Walker, Karl F., automotive engineer, Quartermaster Corps, U. S. A., Washington, assigned to Engineering Laboratory.

Walter, John M., mechanical draftsman, Bureau of Ordnance, Navy Department, Washington.

Waterhouse, W. J. aeronautical engineer, Aviation Section, Signal Corps, (mail) Dayton-Wright Airplane Co., Davton, Ohio.

Weiss, E. A., automobile designer, Quartermaster Corps, U. S. A., Washington (mail), 812 C Street, S. E.

Whinne, Wilbur H., inspector, Quartermaster Corps. U. S. A., Detroit.

White, Percival, automobile expert, Ordnance Department, U. S. A., Rock Island Arsenal, Rock Island, Ill.

Worthen, C. B., inspector, Aviation Section, Signal Corps, U. S. A., Washington.

Recent Additions

Agins, Herman J., Quartermaster Engineering Department, War Department, Washington.

Belling, G. C. C., U. S. Navy Department, Custom House, Boston.

Booth, Fred C., draftsman, Motor Transport Division, Quartermaster Department, U. S. A., Washington.

Bradfield, E. S., Engineering Department, Naval Factory, Philadelphia.

Dick, Robert I., motor truck expert, Ordnance Department, Camp Dodge, Iowa.

Edmondson, D. E., U. S. Signal Service at Large, Washington, assigned as inspector of airplanes and airplane engines, Ericsson Mfg. Co., Buffalo.

Ferry, Phillips B., Signal Corps, U. S. A., McCook Field, Dayton, Ohio.

Grimes, C. P., Signal Corps, U. S. A., McCook Field, Dayton, Ohio, assigned to airplane engineering department.

Guernsey, Chas., Quartermaster Corps, U. S. A., Washington, assigned to Motor Transportation Board.

Harrigan, F. P., Signal Corps, U. S. A., McCook Field, Dayton, Ohio, assigned to Plane Design Section.

Kroeger, F. C., Quartermaster Corps, U. S. A., Washington, assigned as engineer on electrical equipment.

Kuempel, Reuben, Emergency Fleet, U. S. N., Pensacola, Fla., assigned as aeronautical draftsman, Hull Division, Department of Construction and Repair.

Leopold, Jos., Engineers' School, U. S. School of Military Aeronautics, Ohio State University, Columbus, Ohio.

Longletz, Wesley, Signal Corps, U. S. A., assigned as inspector on airplane engines at The Nordyke & Marmon Co., Indianapolis.

Riddle, E. C., U. S. School of Military Aeronautics, Champaign, Ill.

Ruckstell, G. E., Signal Corps, U. S. A., assigned as aeronautical mechanical engineer at Detroit.

Shillinger, G. P., Ground Officers' Engineering School, Kelly Field No. 1, San Antonio, Tex., assigned as instructor in ignition, starting and lighting.

Warner, Edward P., Signal Service at Large, U. S. A., Washington, assigned as aeronautical engineer.

Weiss, Erwin A., War Department, Washington, assigned as automobile designer.

Winter, E. A., War Department, Rock Island Arsenal, Rock Island, Ill.

PERSONAL NOTES OF THE MEMBERS

A. H. Andersen, formerly chief engineer, Mammen & Drescher, Copenhagen, Denmark, is mechanical engineer, A. Hermansen, New York.

C. S. Ash, formerly with the Wire Wheel Corp. of America, Buffalo, is chief engineer and plant manager, National Wire Wheel Works, Inc., Geneva, N. Y.

B. E. Blackley, formerly general sales manager Chase Motor Truck Co., Syracuse, N. Y., is general sales and advertising manager, Larrabe-Deyo Motor Truck Co., Inc., Binghamton, N. Y.

Horace A. Brown, Jr., formerly engineer, sales department, Hyatt Roller Bearing Co., Detroit, is with the United Motors Corp., New York.

W. L. Bonney, formerly aviator, Aero Club of America, New York, is advisory engineer, Briggs Aeroplane Co., Alexandria, Va.

M. Beck, formerly research engineer, Duesenberg Motors Corp., Chicago, is with the same company at Elizabeth, N. J.

William A. Carrel, formerly general superintendent, Beaver Motor Mfg. Company, and superintendent International Harvester Company, is chief engineer and works manager, Erd Motor Company, Saginaw, Mich.

G. M. Carter, formerly general manager, Adams Truck Foundry & Machine Co., Findlay, Ohio, is general manager and vice-president, Adams Axle Co.

H. W. Christensen, formerly chief engineer, The Sayers & Scovill Co., Cincinnati, is with the Lincoln Motor Co., Detroit.

James M. Carples, formerly manager export department, Flint & Co., New York, is with the same company at Washington.

Arthur E. Corbin, formerly general sales manager Pluym-Ochs, Ltd., Russia, is director, Russian Automotive Engineering Co., New York.

George Dunham, formerly consulting engineer, Detroit, is now vice-president The Militor Corp., New York.

E. F. Dickieson, Jr., has severed his connection as manager of the brush sales division, American Carbon & Battery Co., E. St. Louis, Ill.

V. L. Downing, formerly assistant chief draftsman, Nash Motors Co., Kenosha, Wis., is designer, Mitchell Motors Co., Racine, Wis.

E. H. Delling, formerly research engineer Saxon Motor Car Corp., Detroit, is designing engineer, Stanley Motor Carriage Co., Newton, Mass.

Gordon M. Evans, formerly general manager Menominee Motor Truck Co., Menominee, Mich., is consulting engineer, New York.

Raymond M. Everhard, formerly with Cole Motor Car Co., Indianapolis, is final tester and inspector of automobiles, M. C. Kale & Co., Laporte, Ind.

Ethelbert Favary has recently taken charge of a course in motor vehicle engineering that will be given evenings by Cooper Union, New York. The course will include class room work, in which the study of principal parts and the theory will be given and laboratory work, the latter being devoted mostly to engine testing.

Milton D. Frink has severed his connection as field service man of the Anderson Motor Co., Rock Hill, S. C.

Gregory Flynn, formerly sales manager Rajah Auto Supply Co., at Bloomfield, N. J., is with the same company at New York.

E. Gruenfeldt, formerly chief engineer Baker R & L Co., Cleveland, is consulting engineer, 406 Garfield Building, Cleveland.

Wm. R. Gordon, formerly assistant consulting engineer, Pierce-Arrow Motor Car Co., Buffalo, is on the engineering staff, Willys-Overland Co., Toledo, Ohio.

S. E. Gibbs, formerly engineer, Western Carbureter Co., Alma, Mich., is in the engineering department, Moline Plow Co., Moline, Ill.

Harvey W. Harper, manager, Independent Lamp & Wire Co., Weehawken, N. J., is president, Miniature Incandescent Lamp Corp., Newark, N. J.

C. L. Halladay, formerly production manager, Jackson Automobile Co., Jackson, Mich., is with the Automotive Industries Committee, Washington.

F. M. Holden, formerly with airplane engineering department, Signal Corps, Washington, is research engineer, Cadillac Motor Car Co., Detroit.

John O. Heinze, formerly production manager, Simms Magneto Co., East Orange, N. J., is production manager, The Lamson Co., Lowell, Mass.

C. W. Hatch has severed his connection as director of sales, Parish & Bingham Co., Cleveland.

Forrest A. Heath, formerly at Jersey City, N. J., is vice-president, Heath Carbureter Corp., Detroit.

Eugene P. Herrman, formerly president Republic Motor Sales Co., New York, is president, Herrman Motor Truck Co., Inc., New York.

F. D. Howe, formerly superintendent of experiments, International Harvester Corp., at Akron, Ohio, is chief engineer, truck department, with the same company at Chicago.

H. O. C. Isenberg, formerly mechanical engineer, Scripps-Booth Corp., Detroit, is with the Wright-Martin Aircraft Corp., New Brunswick, N. J.

W. H. Knowles, formerly chief engineer, Saxon Motor Car Corp., Detroit, is production superintendent, Hale & Kilburn Co., Philadelphia.

Victor W. Kliesrath, formerly chief engineer, Bosch Magneto Co., New York, is consulting engineer, The Simms Magneto Co., East Orange, N. J.

W. P. Loo, formerly aeronautical engineer, Curtiss Aeroplane Co., Buffalo, is with the Curtiss Engineering Corp., Garden City, New York.

H. M. Leonard, formerly president and chief engineer, L. M. H. Development Co., Jackson, Mich., is president and general manager, Leonard Tractor Co., Jackson, Mich.

C. Long, formerly tool designer, Nordyke & Marmon Co., Indianapolis, is now in the planning department, Foster Machine Co., Elkhart, Ind.

J. H. Liston, formerly manager jobbing department, Standard Parts Co., Cleveland, is general manager, Hipee-States Co., Des Moines, Iowa.

Ethan C. LeMunyon, formerly president and engineer, LeMunyon & Bidelman, Inc., Los Angeles, Cal., is general sales manager, Tractor-Train Co., Los Angeles, Cal.

H. G. McComb is with the Nordyke & Marmon Co., Indianapolis.

George C. McMullen, formerly assistant plant manager of the Timken Detroit Axle Co. of Detroit, is now representing the Timken Bearing Company in connection with the Pacific Coast tractor industry. Mr. McMullen has located in the West on account of poor health of a member of his family. His headquarters will probably be in or near Los Angeles.

Glenn Muffly, formerly manager Muffly Motor Co., Chicago, is engineer of tests, Union Switch & Signal Co., Swissvale, Pa.

A. R. Miller, formerly district sales manager, Gravity Dump Body Co.; Troy Wagon Works Co., Troy, Ohio, is district sales manager, Troy Trailer Co., Troy, Ohio, at Philadelphia.

R. E. Northway, formerly vice-president and general manager, Crescent Motor Co., Cincinnati, is vice-president and engineer, Northway Motors Corp., Boston.

E. A. Oehler, formerly chief engineer, Militaire Motor Vehicle Corp., Buffalo, is assistant chief engineer, Delmore Mfg. Co., New York.

G. H. Peterson, formerly designer and mechanical engineer, Stewart-Warner Speedometer Corp., Chicago, is designer with Champion Ignition Co., Clinton, Mich.

Charles S. Pope, formerly executive, Dodge Bros., Detroit, is assistant factory manager, Elgin Motor Car Corp., Argo, Ill.

E. E. Richmond, formerly production engineer, American & British Mfg. Co., is superintendent, Poole Engineering & Machine Co., Baltimore, Md.

Harlan C. Skinner, formerly with Harry P. Branstetter, Chicago, is in the editorial department, Class Journal Co., Chicago.

Frank M. Strauss, formerly technical advisor, Duffy Motors Corp., New York, is in the service department, Standard Motor Car Co., Pittsburgh, Pa.

George T. Strite, formerly consulting engineer at Minneapolis, is with the Strite Tractor Co., Inc., New York.

H. A. Smith, formerly designer, Bijur Motor Lighting Co., Hoboken, N. J., is chief draftsman with the same company.

R. I. Schonitzer, formerly general manager, Dale Body Co., Fostoria, Ohio, is general manager, The Sidney Mfg. Co., Sidney, Ohio.

Vernon Ira Shobe, formerly New York branch manager, Zenith Carburetor Co., is sales manager with the same company at Detroit.

Lewis H. Scurlock, formerly vice-president and general manager, M & S Gear Corp., Detroit, is president, Kromnik Gear Co., Chicago.

J. C. Slonneger, formerly production engineer, Buffalo-Pitts Co., Buffalo, is with the Holt Mfg. Co., Peoria, Ill.

A. L. Vargha, formerly mechanical engineer and designer, Bour Davis Motor Car Co., Detroit, is designer with Hinkley Motors Corp., Detroit.

ARTHUR C. DURINGER

An attack of heart disease caused the death, on Nov. 15, 1917, of Arthur C. Duringer. Only shortly before his death Mr. Duringer had endeavored to enlist, but was rejected on account of slight heart trouble.

Mr. Duringer was born Nov. 6, 1889, in Buffalo, N. Y. He was elected an Associate Member of the Society on Dec. 14, 1916, when he was chief tool designer with the Militaire Motor Vehicle Co., Buffalo. He was the assistant chief engineer of this company at the time of his death.

JOHN H. HOLLIDAY, JR.

Lieutenant John H. Holliday died Jan. 9, 1918, of pneumonia, at the Georgetown Hospital, Washington. He had been stationed at Washington since his enlistment last October in the Ordnance Department, U. S. A.

Mr. Holliday was born June 14, 1883, in Indianapolis, Ind. He received a general education at the Manual Training School in that city and was graduated in 1905 at the Massachusetts Institute of Technology, with a degree of S. B. He was with the Atlas Engine Works of Indianapolis from 1905 to 1907, where he was connected with the foundry shop work and the foundry engineering department. In 1908 he was with the People's Light and Heat Company, and from 1909 to 1910 with J. G. White & Co., New York. With this company he was the assistant superintendent of construction on powerplant construction at Indianapolis and later at Redonda Beach, Cal.

For three years after 1910 he was the assistant works manager of the Riverside Portland Cement Co., Riverside, Cal., and in 1914 entered the automotive field as president of the Hercules Forge Co., Indianapolis. For two years at this plant he had general management of the company until in 1917 he took up a consulting engineering practice at Indianapolis. He was elected to membership in January, 1917.

Applications *for* Membership

A list of current applications for membership is given below. The members are urged to send any pertinent information with regard to those whose names are given which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

ALLEN, G. EDGAR, president, Allen, Latimer & Co., Inc., *Detroit;* vice-president, general manager, Layman Pressed Rod Corp., *New York.*

ANDERSON, J. D., factory manager, The Fisk Rubber Co., *Chicopee Falls, Mass.*

BALL, RUSSELL C., secretary, treasurer, Philadelphia Gear Works, *Philadelphia.*

BATES, STANLEY EDWARDS, vice-president, chief engineer, Lee Loader & Body Co., *Chicago.*

BEACH, CHARLES S., shop superintendent, Willys-Overland, Inc., *New York.*

BOLGER, ROBERT S., designer, International Motor Co., *New York.*

BRETAUD, JOSEPH V., general superintendent, Swedish Crucible Steel Co., *Detroit.*

BRUCE, V. R., general manager, Hilliard Clutch Machinery Co., *Elmira, N. Y.*

BUDINGER, EDWIN J., designer, springs and layout work, Standard Parts Co., *Cleveland.*

CARINGTON, ROBT. W., representative, lubricating department, Standard Oil Co. of Indiana, *Chicago.*

CARPENTER, CAMPBELL COLON, chief chemist, U. S. Light & Heat Corp., *Niagara Falls, N. Y.*

CARPENTER, FOREST L., layout draftsman, Chevrolet Motor Co., *New York.*

CHILDE, JOHN BRACKETT, vice-president, general manager, The Cleveland Canton Spring Co., *Canton, Ohio.*

CLARK, WILLIAM GIBSON, mechanical engineer, Wilcox Bennett Carburetor Co., *Minneapolis.*

CRAVENS, GEORGE WAVERLEY, chief engineer, works manager, Elkhart Carriage & Motor Car Co., *Elkhart, Ind.*

CURTIS, CHARLES BARTLETT, superintendent, battery department, U. S. Light & Heat Corp., *Niagara Falls, N. Y.*

DEAN, F. A., sales engineer, Hyatt Roller Bearing Co., *Chicago.*

DESAUTELS, CHARLES H., foreman, mold equipment, engineering department, Fisk Rubber Co., *Chicopee Falls, Mass.*

DICKINSON, BIANCO GEORGE C., Canadian Army, *Port Hope, Ont., Can.*

DICKSON, JAMES B., service manager, secretary, Automobile Sales Corp., *Philadelphia.*

EHLERS, PAUL, experimental engineer, Velie Motors Corp., *Davenport, Iowa.*

ELY, HEMAN, secretary, sales manager, Timken Roller Bearing Co., *Canton, Ohio.*

FACTOR, HENRY, draftsman, inspector, Lawrence Aero Engine Corp., *New York.*

FICK, FERDINAND EUGENE, draftsman, tool designer, Nordyke & Marmon Co., *Indianapolis.*

FULMER, CHAS. A., sales engineer, Wasson Piston Ring Co., *New Brunswick, N. J.*

HAMILTON, CHESTER B., manager, mechanical engineer, Hamilton Gear & Machine Co., *Toronto, Can.*

HARPER, CHARLES S., branch manager, Willard Storage Battery Co., *San Francisco.*

HECOX, FLOYD C., captain, military chairman, Board of Motorcycle Engineers, Quartermaster Corps, *Washington.*

HIGGINS, GEORGE H., factory manager, Burd High Compression Ring Co., *Rockford, Ill.*

HOFGAARD, JAMES G., general manager, Torsten Schauman, *Stockholm, Sweden.*

HOWARD, GEORGE MCINTYRE, manager, truck department, Southern Motors Co., *Louisville, Ky.*

HUNKER, EARL M., assistant plant manager, Cleveland Axle Mfg. Co., *Canton, Ohio.*

HUNT, L. G., engineer, Moline Plow Company, Tractor Branch, *Moline, Ill.*

IKERT, B. M., technical editor, Class Journal Publishing Co., *Chicago.*

JAMESON, WILLIAM, advisory engineer, Fisk Rubber Co., *Chicopee Falls, Mass.*

JANDUS, HERBERT S., chief draftsman, The Standard Parts Co., *Cleveland.*

KASTLER, EDWARD L., chief engineer, Holt Mfg. Co., *Stockton, Cal.*

KATZ, ADOLPH, draftsman, Otis Elevator Co., *New York.*

KNISLEY, B. R., superintendent, designer, Hawkeye Mfg. Co., *Sioux City, Iowa.*

LAFRANCE, C. H., president, C. H. LaFrance Sales Co., *Geneva, N. Y.*

LEWIS, GEORGE HENRY, supervisor, experimental work, Fisk Rubber Co., *Chicopee Falls, Mass.*

LINDBERG, ERNEST O., designer, draftsman, Bijur Motor Lighting Co., *Hoboken, N. J.*

LONGWELL, JAMES R., engineer, Curtiss Aeroplane & Motor Corp., *Hammondsport, N. Y.*

MACCALLUM, A. A., branch manager, Hess-Bright Mfg. Co., *San Francisco.*

MCMILLAN, HORACE A., draftsman, Chevrolet Motor Co., *New York.*

MCELROY, JOHN J., chief engineer, Sturtevant Aeroplane Co., *Jamaica Plain, Mass.*

MARQUETTE, MELVON A., assistant superintendent, Fisk Rubber Co., *Chicopee Falls, Mass.*

MATTHEWS, EDGAR M., chassis designer, National Motor Car & Vehicle Corp., *Indianapolis*.

MAUS, JOHN B., export manager, The Fisk Rubber Co., *Chicopee Falls, Mass.*

MAYER, ARTHUR, production manager, bumper department, Edward V. Hartford, Inc., *Jersey City, N. J.*

METZGER, CLAUDE, sales and efficiency engineer, Haynes Stellite Co., and Harvester Co., *Milwaukee*.

MEVIS, GEORGE ARTHUR, salesman, The White Co., *Boston*.

MOFFITT, FRANCIS A., partner, engineer, B. O. Moffitt's Sons, *Binghamton, N. Y.*

MOHR, ALBERT F., engineer, Hyatt Roller Bearing Co., *Chicago*.

MOYET, EDMOND, automobile designer, Andre Citroen Factory, *Paris, France*.

NAYLOR, R. B., chief chemist, Fisk Rubber Co., *Chicopee Falls, Mass.*

OHLIGER, LEWIS P., research and specification chemist, U. S. Light & Heat Corp., *Niagara Falls, N. Y.*

PETTIT, GEORGE HENRY, chief engineer, Atterbury Motor Car Co., *Buffalo*.

PIERSON, THEODORE A., student, Mass. Institute of Technology, *Cambridge, Mass.*

RAPPLEYEA, JAMES CHASE, foreman, assistant to service manager, Willys-Overland Co., *New York*.

RIDDELL, MATTHEW RUTHERFORD, director of testing, Canadian Aeroplanes, Ltd., *Toronto, Can.*

RING, HERMAN B., assistant engineer, Lawrence Aero Engine Corp., *New York*.

ROGGE, LOUIS H., vice-president, treasurer, The Dayton Wire Wheel Co., *Dayton, Ohio*.

RUCK, EDWARD H., chief engineer, The Cleveland Tractor Co., *Cleveland*.

SAWYER, ELIAS N., general superintendent, Cleveland Tractor Co., *Cleveland*.

SCHIRMER, J. O., partner, Schirmer-Frensdorf Co., *Cleveland*.

SCRIBNER, GEORGE KLINE, chief engineer, Boonton Rubber Mfg. Co., *Boonton, N. J.*

SENDELBACH, EDWARD C., manager, wheel department, Rech-Marbaker Co., *Philadelphia*.

SHERRY, RALPH H., metallurgist, General Motors Corp., *Detroit*.

SHIVELY, W. E., experimental engineer, The Goodyear Tire & Rubber Co., *Akron, Ohio*.

SIMPSON, DWIGHT SWAIN, chief engineer, general manager, Palmer-Simpson Corp., *Saranac Lake, N. Y.*

SIMPSON, HOWARD W., layout man, The Buda Co., *Harvey, Ill.*

SINDELAR, EDWARD F., salesman, Beckley Ralston Co., *Chicago*.

SMITH, ELBERT L., draftsman, Barley Motor Car Co., *Kalamazoo, Mich.*

SPURGEON, KENNETH A., general manager, Muncie Gear Works, *Muncie, Ind.*

STACK, JOHN W., representative, lubricating department, Standard Oil Co., *Chicago*.

STAHL, AMBROSE CARL, sales engineer, New Departure Co., *Bristol, Conn.*

TAYLOR, FRANK M., purchasing agent, Smith Motor Truck Corp., *Chicago*.

TEW, JAMES D., assistant superintendent, B. F. Goodrich Co., *Akron, Ohio*.

TUBBS, GEO. E., secretary, works manager, Alamo Farm Light Co., *Hillsdale, Mich.*

VAN DEGRIFT, THOS. C., draftsman, The Dayton Wright Airplane Co., *Dayton, Ohio*.

VAN TINE, HARRY A., chief engineer, Hurlburt Motor Truck Co., *New York*.

VENNER, A. W., superintendent, The Fisk Rubber Co., *Conshohocken, Pa.*

WADSWORTH, HOWARD LUTHER, manager, The Sand Mixing Machine Co., *Cleveland*.

WALTZ, ROY RICHARD, layout engineer, Standard Parts Co., *Cleveland*.

WARFEL, HOWARD A., tool designer, Nordyke & Marmon Co., *Indianapolis*.

WHYTE, JOHN, chief engineer, Bailey Non-Stall Differential Corp., *Chicago*.

WILCOX, ALVA NEWTON, president, The Dayton Wire Wheel Co., *Dayton, Ohio*.

WILHELM, ALVIN J., layout draftsman, Chevrolet Motor Co., *New York*.

Applicants *Qualified*

The following list of applicants have qualified for admission to the Society between December 18, 1917, and January 16, 1918. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

ADAMS, RALPH L. (M) designer, Edw. G. Budd Mfg. Co., *Philadelphia, Pa.*, (mail) 813 S. St. Bernard St.

AGINS, HERMAN J. (J) draftsman, Quartermaster Engineering Div., War Dept., *Washington*, (mail) 1209 N. Capitol St., apt. No. 6.

ALDRIN, EDWIN E. (J) lieutenant, aeronautical engineer, U. S. A., *Fort Monroe, Va.*

BAKER, H. B. (Aff. Rep.) sales manager, The Holt Mfg. Co., *Peoria, Ill.*

BAKER, M. H. (Aff. Rep.) vice-president, factory manager, The Holt Mfg. Co., *Peoria, Ill.*

BARROWS, FREDERICK IRVING (A) secretary-treasurer, charge of legal matters and production, Lexington Motor Co., *Connersville, Ind.* (mail) 455 W. 7th St.

BEIGEL, LINUS (J) draftsman, Franklin Auto Co., *Syracuse, N. Y.*, (mail), 202 Bellevue Ave.

BELLING, G. C. C. (A) assistant inspector engineering material, U. S. Navy Dept., Custom House, *Boston*, (mail) 393 Massachusetts Ave.

BENOIT, LEO G. (A) designer, supervisor, Tips Aero Motor Co., Box 451, *Woonsocket, R. I.*, (mail) 175 Earle St.

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Book Reviews *for* S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described as soon as possible after their receipt, the purpose being to show the general nature of their contents and to give an estimate of their value.

BUSINESS LAW FOR ENGINEERS. By C. Frank Allen. Published 1917 by McGraw-Hill Book Company, Inc., 239 West 39th St., New York. Cloth, 6 by 9 in. 433 pages. Price $3.

The engineer comes constantly in touch with the law in his daily work, so that Mr. Allen's book is of interest, even if it is only used for reference purposes. The author is a former teacher of railroad engineering as well as a lawyer, and as a result the book is perhaps of the greatest interest to civil engineers, particularly those engaged in railroad work. It is divided into two parts, the first covering the elements of law, and the second contract-letting.

According to the author the purpose of the book is not to make every man his own lawyer, but rather to give engineers a sufficient understanding of important fundamental teachings of law, so that they may have some idea of when or how to act themselves and when to seek expert advice, as well as to enlarge their ideas and perhaps encourage them to the further study of law. The members of the society will undoubtedly be most interested in the first part of the book. This starts in with a discussion of the difference between common and statute law, and describes the steps necessary to take in starting a law suit.

Chapter II deals with evidence, and considers the types of direct and circumstantial evidence, and as presented by documents, maps, diagrams, and models. Especially interesting to the engineer who may be called upon to act as an expert in court cases is the part showing how opinions can be presented as evidence.

Contract Essentials

The author states that the four essentials to a contract are: Mutual assent to its terms, competent parties, a valid consideration, and definite and lawful subject matter to be acted upon. Chapter III describes just what is meant by these essentials, and in conclusion describes the modes of terminating a contract.

The classes of offenses known as torts are discussed in the fourth chapter. The author makes the distinction that a tort is an offense against an individual for which the individual should receive redress, while a crime or misdemeanor is an offense that affects the general community, and that the public interest demands should be punished. The torts in which the engineer is mostly interested are offenses connected with the procuring of refusal of contract, breach of contract, the infringement of patents, trademarks and copyrights and perhaps negligence. These and other torts are defined and the method by which they must be established before a court is explained.

Unfortunately, practically no attention is paid to the subject of patents and trademarks, although these are of great interest to many engineers. It is stated that a patent lawyer is essential if a patent is to be secured, and that if further knowledge is required a textbook on the subject should be consulted.

Attention is called to the misconception existing as regards the meaning of equity. Chapter V is devoted to the explanation of the sort of cases that are tried in equity. The principal instruments used in equity are the injunction, a command not to do some improper act; and the mandamus, which positively directs that some act be done. In this way it is possible to remedy wrongs and obtain justice not secured by the common law. The chapter discusses the rights and remedies entering into the domain of equity and shows how such subjects as trusts, injunctions and accounts are handled, both as to the court procedure and as to the rights of private parties in cases when equity assumes jurisdiction.

Chapter VI discusses the law relating to real property, paying particular attention to the method by which deeds are prepared, real estate is conveyed and leased, and concluding with a description of the method by which land is acquired for engineering projects.

Corporation Law

The chapter on corporations, although all too brief, gives a clear description of the method required for forming such associations. The responsibilities undertaken by the stockholders, promoters and others interested in the corporation are explained. The powers of municipal corporations, such as cities, towns, and counties, are described at the end of the chapter.

Chapter VIII, on agency, master, and servant, should be especially useful to engineers who are either employees of companies or delegated to act for others in a technical capacity. In this chapter the workings of employers' liability acts and workmen's compensation laws are considered.

The legal duties of those who are buying or selling commodities are outlined in the chapter on sales. Just what is undertaken when a warranty goes with the goods is described in a general way. The author advocates the adoption of a uniform sales act on account of the diversity in the laws of several states at present. A uniform sales act has already been adopted in about twelve states.

Under the chapter headed "Negotiable Instruments," all forms of commercial paper, such as bills of exchange, checks, promissory notes, are considered. In order to make this matter clear the Negotiable Instrument Law adopted by New York State and also with a little variation by a large majority of the United States, is given in full, together with explanatory note relating to the interpretation of the various clauses.

Chapter XI describes the legal information required by the engineer engaged in the construction or operation of railroads. The responsibilities undertaken by the railroads as common carriers are outlined in order to show just what the requirements of federal and state legislation are.

The last chapter in the first part considers the legal relation of the engineer to others. This is really one of the most valuable parts of the book, inasmuch as it deals with the financial relations of the engineer with com-

(Concluded on page 48, Advertising Section)